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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

Institute of British Foundrymen.

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Education in Relation to Foundry Work.

The Board of Education, through His Majesty's Stationery Office, has just published a Report on education in relation to foundry work.* We are sorry to note that, apart from being a clear statement of the present position, it makes very few and inadequate proposals for its amelioration. The average foundrymen can dismiss the first three sections, which deal with some historical notes of the development of the industry, its extent and character, and the sub-division of the trade—classification of workers—as being common knowledge. In the fourth section we learn that foremen and managers are almost invariably drawn from group (1) (moulders). We seem to remember printing some time ago a letter from a moulder stating the reverse. Actually, there are a large number of successful foundry managers who were trained as patternmakers.

The next two sections deal with recruitment, and contain nothing but oft-repeated foundry platitudes. The Report does, however, contain a serious warning which no foundrymen can afford lightly to dismiss. It says, "There is a lack of suitable entrants, which is so pronounced in character as seriously to menace the future development and prosperity of the industry." In an analysis of the factors adverse to recruitment, the report merely touches upon the economic aspect, when referring to the conditions obtaining in the North of England, and saying the boys prefer to work in the shipyards and mines because of the higher wages paid; but it emphasises, almost *ad nauseam*, the dirty nature of the work. We have yet to learn that coal mining is a cleaner occupation than moulding, yet it is in a position to divert the youthful worker. Candidly, we do not believe any youth minds being dirty whilst at work, providing he has reasonable facilities for washing and changing before returning home. The real deterrent is the untidy and dirty appearance of many foundries. If every one of our readers made a continuous, serious effort to maintain his foundry, or section of a foundry, tidy, clean, light, and well ventilated, we believe the "dirty trade" bogey would disappear reasonably quickly.

The next section—Remedial Measures—is a distinct disappointment, as it merely reiterates the four well-known factors: (1) Recruitment; (2) training in the foundry; (3) school training; and (4) working conditions in the foundry. Then the Report throws the onus of devising a scheme upon shoulders other than the Board of Trade. It says, "The British Cast-Iron Research Association, the Non-Ferrous Metals Research Association, the British Foundrymen's Association [the Institute of British Foundrymen], and the Sheffield Foundry Trades' Technical Society have all shown themselves to be alive to the necessities of the situation, and have made valuable contributions towards the solution of the problem. The present need is for co-operation between the various bodies concerned in formulating and adopting a scheme or schemes which shall be of general application within the industries in question." If by the various bodies the Report means the Associations named, it is ridiculous, for it is axiomatic that "he who pays the piper calls the tune." Therefore, the main parties to any such discussion should be the various employers' federations and the trade unions, with representatives from the educational authorities, technical associations, and research organisations.

In enlarging upon recruitment, the Report suggests publicity in the form of lectures given in the schools and visits of classes to foundries. Colonel Cheesewright, speaking at the opening of the International Foundry Trades' Exhibition at Bingley Hall last Thursday, urged the Midlands educational authorities to arrange for classes to visit the exhibition. This is undoubtedly the best type of propaganda. British boys have a *penchant* for chemicals and machinery, and when seen under spectacular conditions they will so influence their outlook that foundry work will be taken into consideration when choosing a trade.

A reasonably good curriculum is outlined in the report from a national point of view, but the

* Report of H.M. Inspector on Education in relation to foundry work. Published by His Majesty's Stationery Office, Imperial House, Kingsway. Price 4d. net.

modern exigencies of foundry work entail a larger knowledge of metallurgy than, say, a manager of a steel-ingot shop, as a number of new alloys are being introduced yearly. Even at the risk of being thought a crank, we feel that a sound knowledge of metallurgy should be the *but* sought, and elementary subjects leading up to this should be given. Metallurgy is so enlightening that, once a boy has mastered its import, there will be no need to ask him to take up other studies; he will do it naturally.

B.C.I.R.A. to Install Laboratories.

Foundrymen will be interested to learn that the Council of the British Cast Iron Research Association has decided to provide itself with physical, chemical and mechanical testing laboratories. We understand that the Council is taking over a well-known existing metallurgical laboratory in the Birmingham area. The date of opening is stated to be July 1. It is not intended to abandon the system hitherto used of uitilising the laboratories of the universities and members' works. Such parts of the investigations as can conveniently be done at the central laboratory will be carried out there, and the control of the laboratory will considerably increase the capacity of the Association effectively to aid its members.

July 1 commences a new financial year, and the research programme for the year includes the following important investigations:—

(1) Erosion and corrosion-resisting cast iron; (2) mouding sands; (3) automobile cylinders and pistons; (4) graphitisation of iron; (5) heat-resisting cast iron; (6) production of malleable cast iron; (7) cupola practice; (8) cast iron of special electrical and magnetic properties; (9) measurement of melting and pouring temperatures in the foundry; (10) fundamental properties of cast iron; (11) standardisation of test-bars, methods and materials; (12) facing sands, blackings, plumbagos; and (13) cast iron to resist abrasive wear.

Recent new members include:—The Powell Duffryn Steam Coal Company, Boving Engineering Works Company, Limited, J. W. Jackman & Company, Limited, and Younger & Gallon, Limited.

Correspondence.

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

American Specifications for Steel Castings.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—I have noticed in the issue of your Journal for May 15, 1924, an article entitled "The Manufacture of American Steel Castings," by Mr. W. H. Woodhall.

The author makes a reference to specifications which is misleading. Mr. Woodhall states:

"Most work in a tonnage foundry is of the railway class of castings. A summary of this type of specifications follows:

"1. Scope. These specifications cover all steel castings for passenger and freight equipment cars, including couplers, truck bolsters, truck side frames, yokes, and miscellaneous castings.

"4. Chemical Composition. The steel shall conform to the following requirements as to chemical composition: C, 0.20 to 0.37; Mn, not over 0.75; P, not over 0.05; and S, not over 0.05 per cent."

In the above quotation I have omitted paragraphs that do not relate to the matter to which I invite your attention.

One who is not personally familiar with the circumstances would infer from a reading of these clauses in the specifications which are presumably typical of those covering steel castings for railroad use in the United States, that such specifications generally prescribe limitations for carbon content and a maximum limitation of 0.75 per cent. manganese content.

The American Railway Association and the American Society for Testing Materials, acting together, tentatively adopted in 1922, specifications for carbon steel castings for railroads which still have a tentative status, or in other words, are on trial pending a decision as to their suitability before advancing them to a definite and standard classification. These specifications (A87-22T) contain the following section relating to chemical composition:

"25. The steel shall conform to the following requirements as to chemical composition:—Manganese, not over 0.85; phosphorus, not over 0.05; and sulphur, not over 0.05 per cent.

The specifications just referred to are not binding on any consumer. They are, however, naturally taken as the basis for purchase requirements of many railroads and constitute the only specifications existing at present for railroad steel castings having a general rather than a local significance. There are many railroads which impose limitations as to chemical composition only for phosphorus and sulphur. A disposition to prescribe a maximum limitation of 0.75 per cent. managanese does not characterise the general sentiment of engineers of tests of the railway systems in the United States. Furthermore, the tendency which resulted in a maximum limitation of 0.85 per cent. manganese in tentative specifications A87-22T has, as yet, been followed by no general movement on the part of American consumers of steel castings to similar effect.

Without question, the tendency of consumers of steel castings in the United States is toward no restrictions on the manufacturer as to how he shall make his product to conform to definite and exacting physical requirements, excepting only certain restrictions as those relating to phosphorus and sulphur which are generally believed to be important in assuring a thoroughly satisfactory product.

The point just made is illustrated by the tentative adoption in 1923 of revised specifications for steel castings for general purposes. These specifications are now in effect as tentative and provide no maximum limitation as to manganese content; maintain a maximum limitation of 0.05 per cent. for phosphorus in basic steel and one of 0.05 per cent. for the same element in acid steel; prescribe the maximum limitation of 0.06 per cent. for sulphur; and stipulate that Class A castings shall have a carbon content not exceeding 0.45 per cent. Castings in Class A are of an inferior grade for which no physical requirements are specified.

In the progressive movement to stimulate the formulation of specifications along thoroughly consistent lines published information indicating a different tendency is to be regretted, particularly when it is incorrect.—Yours, etc.,

R. A. BULL.
Research Director, Electrical Steel Founders' Research Group.
June 11, 1924.

Output of Pig-iron and Steel Castings.

According to statistics issued by the National Federation of Iron and Steel Manufacturers, the production of pig-iron in May amounted to 650,900 tons, compared with 618,400 tons in April and 714,200 tons in May, 1923. The number of furnaces in blast at the end of the month was 191, a reduction of three since the beginning of the month. The production includes 194,900 tons of hematite, 239,300 tons of basic, 148,800 tons of foundry, and 37,400 tons of forge pig-iron.

The output of steel ingots and castings in May amounted to 809,700 tons, compared with 711,500 tons in April (when production was affected by the Easter holidays) and 821,000 tons in May, 1923.

CUMBERLAND iron ore miners' wages are reduced slightly, consequent upon the fall in the monthly ascertainment price of Cumberland hematite iron, mixed numbers, which showed a reduction of about 10.49d. (from £5 1s. 8.22d. to £5 0s. 9.73d.). The decrease in wages is but slight, and will last until about the middle of next month, the principal new rates being as follows (per day or shift in each instance):—Miners' working bargains, 10s. 1d.; miners' minimum, 7s. 5d.; underground labourers, 6s. 5d.; blacksmiths, 9s. 2d.; chargemen, mineral shot borers and joiners, 9s. 2d. (plus allowance for tools, etc.); winding enginemen, 8s. 9½d.

The International Foundry Trades' Exhibition.

BINGLEY HALL, BIRMINGHAM.

Opening Ceremony.

Mr. H. Lakin-Smith, President of the Birmingham Chamber of Commerce, presided at the opening ceremony, and was supported by Mr. R. O. Patterson, of Newcastle-on-Tyne (President of the Institute of British Foundrymen), Mr. J. Percy Plant, Chairman of the Exhibition Committee, Col. W. F. Cheesewright, and others.

Previous and Present Efforts.

MR. LAKIN-SMITH said it would be recalled that about two years ago the first International Foundry Trades Exhibition was held in Bingley Hall, Birmingham. It was organised by the Birmingham Chamber of Commerce, the Institute of British Foundrymen and the British Cast Iron Research Association, and was so successful—thousands coming from all parts of the country, and also representatives from America, France and Belgium—that it was thought desirable by the same three Associations to repeat the experiment and have a similar exhibition this year. The present exhibition was representative of all the best interests, and promised to be as great a success as its predecessor. They believed that not only did the public and those particularly interested in the foundry trade learn a great deal from an exhibition of that kind, but that in addition it assisted in the revival of trade which had been so long coming since the slump in 1920-21. There was a section of people who since the war had not shown their former energy in trying to meet the needs of the country and assisting in the revival of trade. Such an exhibition as that should prove a stimulus to those people by bringing to their notice the good work which was being done. In Birmingham and elsewhere they were energetically trying to wake up the country to the urgency of improving trade. There were already signs of movement, but a great deal remained to be done. They were particularly fortunate in having with them to open the Exhibition Mr. R. O. Patterson, who had specially travelled from Newcastle-on-Tyne for that purpose.

Growing Importance of Foundry Machinery.

MR. PATTERSON said he had only been President of the Institute for some two weeks, and it was very gratifying to him to have been called upon to preside over such an important gathering. For some years he had been trying to push the installation of labour-saving devices in foundries generally and in his own foundry particularly, and it had been against really serious opposition. At that Exhibition they saw what they had long desired to see—the moulding machines and labour-saving devices for the foundry in actual operation. The Exhibition was what progressive British foundrymen had been waiting for for many years. Their friends on the other side of the Atlantic had had such exhibitions yearly for a considerable time, the result being that they had progressed by leaps and bounds in the rapid production of cheap castings.

Coming Shortage of Skilled Labour.

At home we were faced with the difficulty of getting adequate skilled labour. In a sense it had been fortunate for us that we had been passing through a time of serious depression. Had there been an adequate volume of trade, such as was required to keep the works in full operation, there would not have been the skilled labour available. During the depression—he was speaking of the North-East Coast—they had lost an enormous number of skilled men out of the foundry trade who had emigrated to America. Of course, it was always the best men who emigrated; they were the only men who had the money to pay their passage. Further, every branch of the engineering trade, owing to the depression, had been unable to pay the skilled men adequate wages, with the result that many men had left the trade and gone into municipal employment, where they were at any rate guaranteed a regular job. They could not blame the men for going. It was only natural that they should improve their position if they could. The fact remained, however, that they would not come back to the foundry trade, and when they did get busy the position at the foundries would be a difficult one. It took a boy five or seven years' training before he became a moulder, and that was not fast enough if trade revived at an early date, as they hoped it would. Therefore they would be bound to use such machinery as they saw exhibited in that hall.

Cast-iron Requires Publicity.

They were bound, if they wanted to keep their heads above water, to cheapen their products. They must push cast iron down the public's throat. The consumption of cast iron must be increased enormously. Unfortunately, they could not make people eat it—(laughter)—but they ought to see that they fried their morning's bacon on it. It was only by propoganda work such as the Exhibition was accomplishing that they could successfully push their goods. There certainly ought to be some special organisation to assist them in this direction, because until they had an adequate output from the foundries their overhead charges would be such as to preclude them from selling their goods. To a great proportion of the country the labour-saving machines and tools were new. The Institute of British Foundrymen was doing its best to educate young foundrymen and to equip them with complete knowledge of their business. In years to come these men would come along and be the managing spirit in the foundries. In the meantime we must proceed slowly, but it was necessary to get to work at once to produce, more or less, a race of foundry engineers. By that he meant men who were actually foundrymen, but also engineers. They did not apply engineering principles in the foundry to the extent that they ought to. (Hear, hear.) The Institute had done immense work in this respect, and was still continuing.

The B.C.I.R.A.

In addition, there was the Cast Iron Research Association. This Association was progressing now by leaps and bounds, and it was very gratifying to all of them to find that at last it was beginning to be taken notice of. It gave its members technical advice on all subjects, and he was quite sure would do an immense amount of good in the very near future. As foundrymen they thanked the Birmingham Chamber of Commerce for having organised the Exhibition for their benefit. The Chamber stood for stability in trade, which was badly wanted. The Institute of British Foundrymen and the Cast Iron Research Association stood for the education of the foundryman. He thought a closer fusion of commercial and technical associations was very badly required in this country. They were all working for their good, and deserved their heartiest support. Mr Patterson closed by declaring the Exhibition open, and wishing it every success.

Vote of Thanks.

Proposing a vote of thanks to Mr. Patterson, MR. H. J. SAYER described Birmingham as a city ancient in its devotion to the science of metals. He emphasised the need for efficiency, remarking that machines which were good enough for our forefathers were no good at all in the race of to-day. To manufacturers who objected that they could not afford to scrap obsolete machines, he would say that they could not afford not to scrap them, because they were losing money by keeping them on. In the machine shops of the Continent he had seen nothing superior to what we possessed, and though we spoke of the difference in the rate of exchange, from what he saw the wages being paid were quite equal to ours, while living was, if anything, dearer. We ought, with the brains and machinery we possessed, and our great resources, to hold our place in the markets

of the world. He had no fear that we should not do so.

MR. J. P. PLANT, in seconding the motion, described the foundry trades as the key industry upon which other industries depended, and said that upon their energy and enterprise was largely dependent the future well-being and prosperity of the country. He spoke of the tremendous scope of the industry, which, he said, had a wonderful prospect, and in closing congratulated the exhibitors and wished them all the support that their initiative deserved.

Missed Educational Opportunities.

Speaking in support of the motion, COL. W. F. CHEESEWRIGHT referred to the difficulty of getting boys into the foundry, and suggested that good might be done by permitting boys from the schools to visit the Exhibition. If that were done it might prove easier later on to secure more foundrymen and to persuade them to take up the higher branches of technical education. There was not the slightest doubt that in the foundry trade to-day there were very good positions indeed for men to make for themselves.

The resolution was carried with acclamation, and Mr. Patterson briefly acknowledged the compliment.

mounted on heavy double slides which insure perfect accuracy and stability even on the heaviest work.

The machine is fitted with a rising and falling table with horizontal movements in both directions for slot mortising and boring, and with a tilting front table for light sawing, ripping, cross-cutting, mitreing, moulding, rebating, tenoning, etc. All kinds of cutter blocks and cutters can be used on this part of the machine, which is fitted with two adjustable fences, vertical and lateral pressure springs, and can be tilted out of the way when not in use, so as to give easy access to the surfacing table.

Another machine of great interest is a self-contained tenoning machine with canting table and swinging fence. It is extremely compact, and both spindles are driven from the same belt. It is fitted throughout with ball bearings, and also with an independent circular saw spindle for cross-cutting at all angles.

Danckaert 32-in. Band Saw.—The design of its frame, the construction of its working parts, with ball bearings placed in the axis of the saw wheels, and its new automatic saw straining device which works on the knife edge principle, and is instantaneously adjustable to any width of blade, make it a really modern machine.

THE STAND OF "THE FOUNDRY TRADE JOURNAL" AT THE BIRMINGHAM EXHIBITION.

More Exhibits Described.

J. A. Victor.

Mr. J. A. Victor, whose office is at 77a, Queen Victoria Street, London, E.C.4, is exhibiting a number of wood-working machines by the Ateliers de Construction Ch. Danckaert, of Brussels, for which he is sole selling agent in this country.

The most attractive exhibit is a universal wood-worker, specially constructed to meet the requirements of small shops where a variety of different operations must be performed in a short time and generally by one man. This is the case of a number of pattern shops where there would not be enough room nor work for a complete plant of separate machines. This machine is built upon the main frame of a standard combined planing and thicknessing machine, and is capable of thicknessing timber up to 15 in. × 9 in. exactly in the same way as would an ordinary panel planer. As this operation is undoubtedly by far the heaviest and most difficult which may be required in connection with ordinary joinery or coach work, the value of the machine will be immediately recognised.

It is fitted with a circular safety cutter block with patent automatic knife-setting device, and revolving in heavy Skefko double-row ball bearings, and both the surfacing and thicknessing tables are

Spindle Moulder.—This has an exceptionally large top bearing and slide, lift-up table, and a number of different heads, cutters, and accessories.

Hand Planing and Jointing Machine.—This exhibit has very long tables, 8 ft. in length overall, supported on heavy double slides.

Rising and Falling Table Sawbench.—This machine has a canting fence fitted with fine adjustment screw, latest safety guards, and several accessories. It is suitable for any kind of wood-working shop, and can deep 8 in. as well as rip, cross-cut, mitre, rebate, etc.

The exhibit is completed by an automatic saw sharpening machine for circular saws up to 42 in. in dia., and also for band saws and frame saws. It is an adjustable machine, and it will entirely finish any kind of saw in one single operation, as the emery wheel will follow the tooth right round and bevel the top as well.

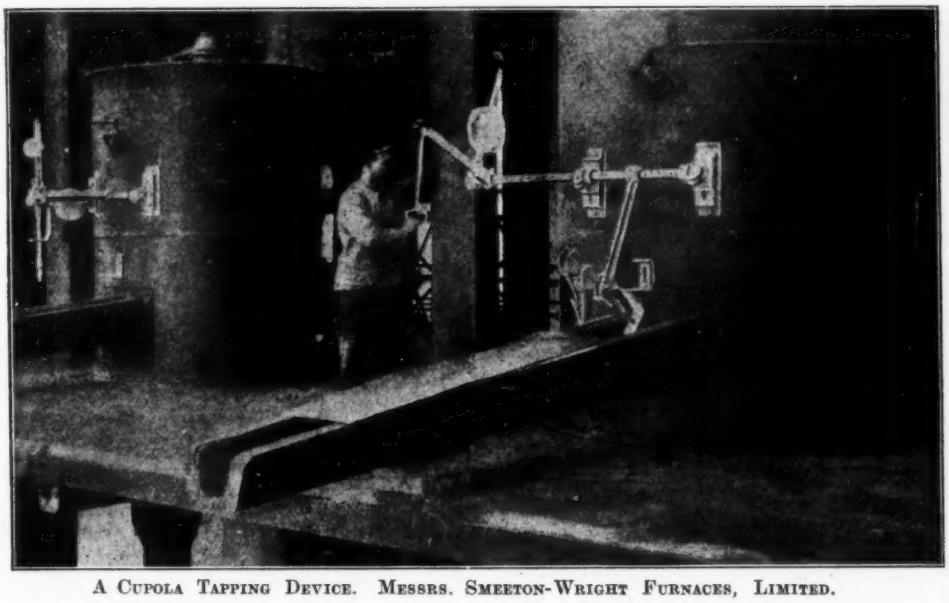
The stand is in charge of the Midland agent, Mr. P. Bramwell Newell.

Penton Publishing Company.

This firm of engineering and technical publishers, whose offices are at Cleveland, Ohio, have on their stand literature and photographs relative to their papers—"The Foundry" and "The Iron Trades Review."

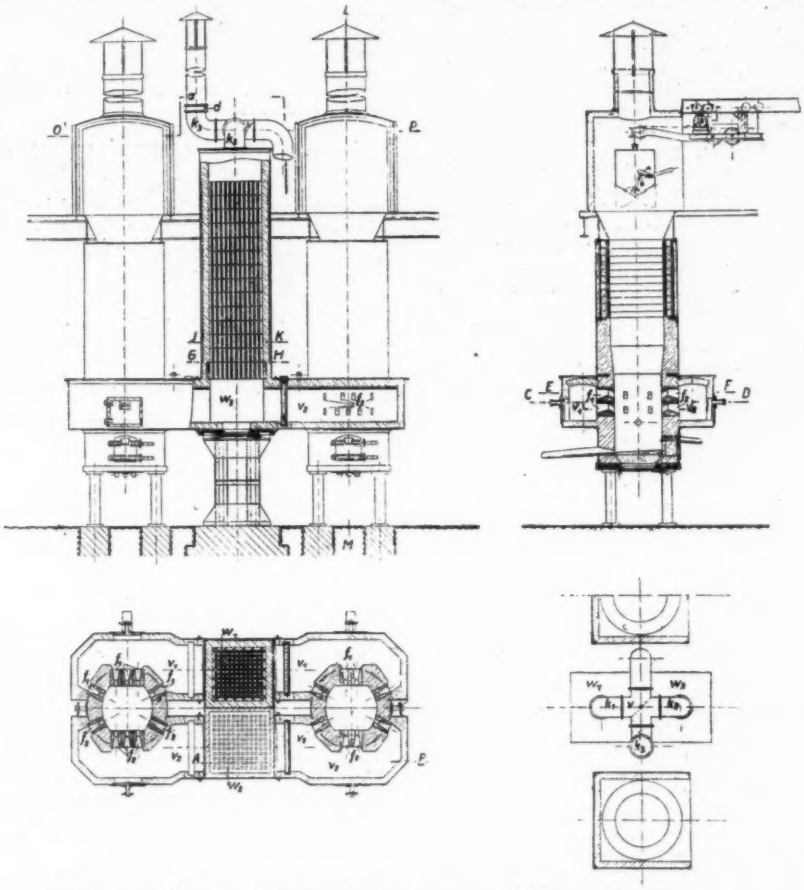
Smeeton-Wright Furnaces, Limited.

Though well known in steelworks circles, this firm, whose office is at St. Stephen's House, Victoria Embankment, London, S.W.1, has only recently interested itself in foundry plant and supplies by forming a section to deal with a number of Continental specialities.



A CUPOLA TAPPING DEVICE. MESSRS. SMEETON-WRIGHT FURNACES, LIMITED.

Schurmann Cupola.—A model and a series of working drawings, together with a large amount of data are being shown of this interesting invention. The underlying principle is the suppression of the endothermic (heat-absorbing) reaction $CO_2 + C = 2\,CO$. This is accomplished by interposing a minimum amount of red-hot carbon (coke) in the path of combustion, or in other words, the blast is not allowed to pass up the stack, but made to traverse directly across the cupola. Commonsense insists that it would be ridiculous to let this heated gas pass into the atmosphere, and so a regenerative system has been incorporated.



SECTION AND PLAN OF THE SCHURMANN CUPOLA. MESSRS. SMEETON-WRIGHT FURNACES, LIMITED.

This system, originally devised by Siemens, is based upon the dispersal of the heat to a set of chequers, and then by a reversing system, utilising this heat to warm up the gases to be used for

combustion, during which time the waste heat warms up a second set of chequers.

Theoretically this system has much to commend it, and apparently it is doing well in Germany, and its development in Great Britain will be keenly followed by all progressive foundrymen.

Gutman Sand-Blasting Machines.—Owing to the proposed new cleaning of castings regulations, much interest is centred round this branch of foundry work. All the well-known types are shown by photographs, such as the sand-blast room, pedestal, and revolving table types. Rotating sand-blast drums present many points of interest. Two types are being shown.

Gutman Hydraulic Moulding Machine.—This machine, whilst incorporating hydraulic squeezing, releases the pattern by mechanical means. This is stated to give a very true and easy stripping with a lowered power consumption.

Cupola Tapping Device.—This simple apparatus has been patented by Herr Hermann Meyer, a foundry owner of Bremen. It has been applied to over 1,000 cupolas in Germany, and is designed to eliminate entirely botting in, which after all is always accompanied by a slight amount of danger if carried out unskilfully. It is a simple arrangement of levers and balance weights, and the plug is stated to last many weeks. It is equally applicable to either a cupola or a receiver.

Ladles.—Two ladles of the Collin type are being shown. This make incorporates an air-cooled belt with a tilting mechanism provided with ball-bearings and enclosed in an oil bath.

Chantraine Furnaces.—A model of a Chantraine furnace which has many metallurgical applications completes the exhibit. Mr. John A. Smeeton will be in charge of the stand.

The Adaptable Moulding Machine Company.

The Adaptable Moulding Machine Company, of Stanhope Street, Birmingham, have a representative collection of hand-moulding machines.

Standard Type Adaptable Moulding Machines of the latest design, and having a range for taking pattern plates from 12 in. to 20 in. in width, with a 6 in. draw. These machines are so designed that the length of plate is not restricted, but it is not usual to exceed 30 in. length.

Large Type Adaptable Machine are shown having a capacity of 18 in. to 26 in. in width, with a 6 in. draft. These machines are similar in principle to the standard type. Various pattern plates are shown on the machines at work. The machines can be fitted with double lift attachments where it is desired to secure a deeper draft than the 6 in., or where it is necessary to draw the pattern and then lift the moulding box off the stripping plate. Turnover attachments can also be fitted where match plates are used or deep green-sand cores are to be made up in the moulds. Both these devices will be shown where it is required to make up the green-sand cores in the mould.

"*Duplex*" *Rollover Machines* have a 12 in. draft suitable for deep green-sand cores or moulds. The weight of the mould or core is turned over in the dead centre of load, thus requiring the least possible amount of energy for the purpose. The moulds can also be rammed up near the floor-line, resulting in a saving of labour during the ramming process. The machine is so designed that there is a machine arranged on each side of the central column, and each machine can be used independently of the other. If desired, the machines can be fitted with a special bracket to carry match plates.

Adaptable Core Machine for split core-boxes has a draw of 12 in. Existing core-boxes can be fitted, and the machine is so designed that the core-box carriers can be moved into horizontal position for ramming up intricate pockets.

Piston Type Core Machine is designed for the production of piston cores on quantity basis. The core is rammed up on a table, which is adjustable to suit the height of core-box, and then rolled over on to another adjustable table; the opening movement being 6 in.

Duplex Sifters are for hand, belt or motor-drives. On these machines the riddles can be changed whilst the machine is in motion, thus enabling two grades of sand to be worked with one machine. All working parts are totally enclosed. The power required is exceedingly low, and the maintenance charges are exceptionally small.

Moulding Boxes are shown in cast iron, rolled steel of $\frac{1}{16}$ in. and $\frac{1}{4}$-in. section, pressed steel boxes in 10 and 12 gauge section, and a range of snap flasks are on view.

Mr. W. O'Keefe, the proprietor, is personally taking charge of the stand.

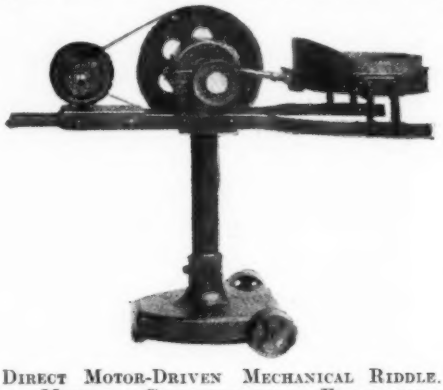
The Constructional Engineering Company, Limited.

This firm, whose office is at Titan Works, Charles Henry Street, Birmingham, are showing their well-known cupolette, lined with firebricks, complete with motor-driven fan, all forming a self-contained unit with a melting capacity of 1 ton per hour.

An improved type of belted cupolette is shown fitted with Wood's patent blast control arrangement. This plant has a melting capacity of 30 cwts. per hour. It can be mounted on standards or included in steel framework, with staging, roof, hoist, etc.

A "Titan" mechanical sand riddle is shown working. It is fitted with motor complete.

A new type of under-geared sand mill is shown complete with fast and loose pulley for belt driving.



DIRECT MOTOR-DRIVEN MECHANICAL RIDDLE. MESSRS. CONSTRUCTIONAL ENGINEERING COMPANY.

Amongst the ladles shown is an 8-cwt. bogie ladle mounted on two wheels, complete with loose handles for drawing and tilting. There is also a good range of pressed steel ladles fitted in weldless steel shanks. The capacities are from 28 lbs. to 15 cwts.

A range of various sizes of pressed steel moulding boxes is shown. These are interchangeable, and are fitted with turned pins and renewable bushes.

Patent tubular steel clamps; moulders' boards; bellows; riddles; sieves; chaplets; wax core vents; and general foundry requisites complete the exhibit. Mr. D. H. Wood is in charge of the stand.

The Donington Sand Company.

The quarries of this well-known moulding sand concern are at Wellington, Salop.

The Donington sand is a natural bond moulding sand, and has the following advantages:—Composition:—Silica, 92.10; ferric oxide, 1.60; alumina, 5.04; lime, 0.13; magnesia, 0.10; and loss on ignition, 0.88 per cent.

The stand is in charge of Mr. Thomas Vickers, of 14, New Street, Birmingham.

The Britannia Foundry Company, Limited.

This well-known firm of moulding machine manufacturers, whose foundries are at Cox Street, Coventry, are showing seven types of machines. They are as follows:—(1) No. 0, "Britannia" jar ram moulding machine, has a self-contained lifting apparatus. It will ram and lift moulds up to 5 cwt. (2) No. 1 "Britannia" jar ram moulding machine. This is a similar machine to the No. 0, but will ram up to 10 cwt. These machines are built in other sizes up to 2 tons capacity. (3) No. 00 "Coventry" turnover jar ram moulding machine. This machine is applicable to 18 in. sq. (4) No. 1 "Coventry" turnover jar ram moulding machine. This type has a capacity of 8 cwt. The pattern draw is 15 in. Both this and the previous one are very rapid machines. (5) "Coventry" jar ram squeezer moulding machine.—This pattern is suitable for moulds up to 19 by 14 in. It has a combined pattern-stripping attach-

ment. This is its first public exhibition. (6) "Coventry" patent head-ram moulding machine.—This is a hand-operated machine, and is suitable for moulds up to 16 by 14 in., with an 8 in. pattern draw. By the patent gear used on this machine a pressure of 5 tons on the mould can easily be obtained. (7) "Adjustable" hand-rammed moulding machine.—This type has an 8-in. pattern draw; it can be adjusted to take boxes from 8 in. sq. to 34 in. sq.

Other notable exhibits are the "Duplex" foundry sand mixer, which will mix 5 tons per hour; interchangeable moulding boxes; pattern plates; enamelling ovens; and gas, coke, steam, or electrically heated core ovens.

Mr. C. Scrampton is in charge of the exhibit.

John Macdonald and Company.

This firm, whose works are at Pollokshaws, Glasgow, exhibit a number of types of "Cleveland" pneumatic tools for foundry service, including sand rammers for floor and bench work.

Portable pneumatic grinders of the latest design are shown, having one-piece connecting rods. Size 7 runs at 4,600 r.p.m., with 4 or 6 in. dia. wheel. Size 8 runs at 3,600 r.p.m. with an 8 in. wheel.

Another interesting exhibit is a range of chipping hammers with the "protected" type of valve, for fettling castings.

"Bowes" automatic air-tight hose coupling is

A BALL-BEARING ELECTRIC SAND RIDDLE. MESSRS. JOHN MACDONALD & COMPANY.

an exhibit of more than ordinary interest for the average foundry.

Portable Electric Sand Riddles.—This machine comprises a ¼ h.p. motor, which is wound for all voltages, is shown working through a worm gear to a crankshaft, giving an elliptical motion to the riddle, thus eliminating the necessity of lump-breaking plates or attachments which wear out the screen. The portable feature of the riddle makes it easy to move to any desired part of the foundry. All working parts are entirely enclosed and thoroughly protected from sand. The running cost is stated to be very small.

R. J. Richardson and Son, Limited.

This firm, whose offices are at Commercial Street, Birmingham, has had for Birmingham and district the sole representation for a great many years of Messrs. Tilghman's Patent Sand Blast Company, Limited, Broadheath, Manchester; Messrs. Samuelson & Company, Limited, Banbury; Messrs. Geo. Green & Company, Keighley; and Messrs. David Bridge & Company, Limited, Castleton, Manchester. They are exhibiting an air compressor of Messrs. Tilghman's manufacture which is one of the vertical two-stage, single-acting type compressors, and gives a pressure of 90-100 lbs. per sq. in. This compressor is supplying all the air in connection with the various requirements of exhibitors. Other items which are on exhibit are sandblast apparatus, articles both before and after sandblasting to show the various results of the sandblasting operation; Roots' Acme blowers; moulding machines; cupolas and other foundry plant. This firm also represents the Manchester Furnaces, Limited, Ashton New Road, Manchester, in connection with furnaces for all duties.

Yorkshire Amalgamated Products, Limited.

This firm, whose offices are at 27, Waterdale, Doncaster, specialise in foundry sands.

Red Moulding Sands.—These are the well-known Bunter deposits at Heck, Hensall and Doncaster, supplied as quarried, crushed or well milled.

Steel Foundry Sands.—These are quarried at Huttons Ambo, Pickering, and South Cave. They are exceptionally strong, highly refractory bonding sands for steel and special iron mixtures, and are equal to imported Continental sands. High silica sands for mixtures, which are uniform in quality and of even grain-size ensuring maximum venting, are also shown.

A speciality is made of sands expressly prepared for light iron castings and non-ferrous alloys. *Sand Slingers and Moulding Machines.*—Samples of ground cupola and ladle ganister, silica cement, silica flour, fluxing stone for cupolas, and high silica sand for furnace bottoms are available for inspection. Silica bricks for open-hearth, electric and converter steel furnaces, manufactured at their works at Bawtry, Yorks, constitute an interesting range, which is supplemented by insulating bricks, firebricks and blocks for cupola linings. "K. B." core binder is a new preparation for steel, malleable iron, brass and aluminium castings.

Thomas E. Gray and Company, Limited.

This well-known foundry supply house, whose offices are at 119, High Holborn, London, W.C.1, are showing "Silacene," a plastic refractory which is used for lining cupolas and every kind of acid furnace. Ganister, parting powder, iron cement, non-ferrous flux, blacking, plumbago, coal dust, foundry coke, furnace coke, sand, french chalk, and core gum constitute one of the most interesting ranges of foundry raw materials in the exhibition.

The "Easilit" Blow Lamp Company, Limited.

This firm, whose works are at 34, Watford Road, King's Norton, Birmingham, as their name indicates, specialise in blow lamps with a patent starting-up device. Paraffin blow lamp to start without pre-heating; new pattern continuous branding iron, without re-heating, suitable for planks and ladders, and "Yates' Patent Hot Grate," constitute an exhibit of which the main application in foundry work is the skin drying of moulds.

W. and T. Avery, Limited.

There is no firm better known to the foundry industry than Messrs. W. & T. Avery, of Soho Foundry, Birmingham. Their exhibit has been carefully thought out to meet the needs of the foundry industry. The 2,000-lb. portable deal platform weighing machine is suitable for general foundry use. Of interest, too, for foundries is their patented spool nett weighing and counting machine. On the testing side they are showing a 10-ton universal machine for torsion and tensile tests, and a foundry bar-testing machine for tensile and transverse tests.

Merry and Cunninghame, Limited.

This well-known firm of iron and coal masters, whose registered office is at 127, St. Vincent Street, Glasgow, are confining their exhibits to "Glengarnock" and "Carnbroe" brands of Scotch pig-iron.

The Selas-Turner Company, Limited.

This firm, whose offices are at City Road, Manchester, specialise in gas furnaces. The basis of their furnaces is incorporated in a patent automatic gas and air mixing apparatus, which is stated to give a uniform mixture under all loads. It is shown applied to a "Selas" metal melting tilting furnace, which is used for all classes of non-ferrous metals. No crucibles are required, and the lining has an exceptionally long life.

"Selas" patent furnaces are designed to suit individual requirements. They are suitable for melting, forging, normalising, annealing, carburising, hardening, core drying, enamelling and tinning. Other exhibits are blowpipes, tinmen's stoves, soldering irons and a range of furnace burners.

The stand is illuminated with "Selas" lamps of varying candle powers. The guaranteed gas consumption for the "Selas" system is 2 cub. ft. per 100 c.p. lamp.

The British Cast Iron Research Association.

The Association, whose offices are at Central House, New Street, Birmingham, is perhaps the most interesting in the Exhibition. A chart illustrates the growth of the Association over the last three years, and its director is to be congratulated on the progress shown. A number of excellent micrographs show the effect of quenching a sample of cast iron from various temperatures. Another interesting exhibit is Mr. Fletcher's apparatus for determining the constitution of moulding sands. Along one side of the stand are arranged a number of specimens showing defects, but in every case a reasonable explanation is given. Mr. H. J. Young, of the North-Eastern Marine, has lent a number of very beautiful tinted microphotographs of cast iron. The stand is in charge of the Director, Mr. J. G. Pearce, who will give foundrymen the fullest details of the work of the Association and benefits to be enjoyed by joining it.

Industrial Research Laboratories, City of Birmingham Gas Department.

The Industrial Research Laboratory stand is divided into two sections—one of which is devoted to exhibits of various forms of testing apparatus and appliances used in connection with the investigation of the properties of ferrous and non-ferrous material. This exhibit includes the following:—

A 10,000 lbs. single-lever tensile and compression testing machine, manufactured by Messrs. W. & T. Avery, Limited.

A recent type of dead weight Brinell hardness testing machine manufactured by the same firm.

A complete metallurgical microscope by Messrs. W. Watson & Sons, Limited, London, is also shown with projector to enable structures of ferrous and non-ferrous material to be examined at high magnification, the screen being replaced by a camera for photographic reproduction if required. This apparatus will be shown in actual use, and demonstrations will be given from time to time during the Exhibition.

Another interesting exhibit is a cathode ray oscillograph made by Messrs. the Western Electric Company, by means of which hysteresis loops are plotted for various magnetic material, including cast iron, wrought iron and steel. The loop is traced out on the opalescent bulb of the thermionic valve by means of a magnetic cathode beam which is deflected simultaneously in two directions at right angles.

Gas Furnace Section.—This section includes a natural draught gas-heated oven furnace, made by Messrs. Lucas Furnaces, at work. This furnace is suitable for the general annealing, hardening, and case-hardening operations required for the majority of engineering shops to-day, and is also suitable for the heating up of dies prior to metal casting.

Gas is supplied to the furnace at ordinary town pressure, and the waste gases, leaving the front of the furnace near the door, pass through a series of "Recuperator" tubes over which the secondary air required for completion of combustion is passing, thus being pre-heated and leading to a considerable economy in gas consumption.

Further, a standard double-cased gas-heated stove, of a small size suitable for the drying of cores and similar operations, is demonstrated, fitted with the latest type of burner for this class of work.

A re-melting pot heated by a high-pressure gas burner is shown at work, and is typical of the type of furnace which is being used for aluminium re-melting for die-casting processes. This furnace is fitted with iron-pot, and the interior brickwork is shaped to the outline of the pot.

In addition to the above, a series of various sizes of blowpipes are shown.

The Carborundum Company, Limited.

The Company, whose works are at Trafford Park, Manchester, are manufacturers of the original carborundum grinding wheel which is used for the grinding of cast iron, chilled iron, brass, phosphor bronze, and unannealed malleable. It is also a very suitable wheel for the grinding of aluminium.

The Aloxite wheel is a sister product suitable for the grinding of steel, malleable iron, and all high tensile metals.

Other important products used in the foundry dressing shops are the carborundum and Aloxite scrubbing stones for the scrubbing of iron and steel castings. Carborundum and Aloxite double-coated cloth-back discs also play an important part in dressing up castings, due to the fact that there is such a variety of coarse grits from which to choose.

Carborundum refractories are made for use in all class of furnaces in various shapes, including bricks, muffles, retorts, cements, etc. All carborundum refractories are high mechanical strength under heat conditions and high thermal conductivity.

Thomas & Bishop, Limited.

Messrs. Thomas & Bishop, of 37, Tabernacle Street, London, E.C.2, have an interesting exhibit, which shows belts, after treatment with "Cling Surface," running slack at full load. Two types of refractory cements are shown, known as "Flexo" A and B. The former is for very high temperature use and the latter for boiler flue and bridge work.

They also show an oil reclaiming plant for dealing with dirty oil taken from engine sumps or other parts. The product is a pure, clean oil, free from carbon. The machine is entirely automatic, and is worked with water only. It is an entirely new process for oil reclaiming under a patent just granted in England to an Australian company. The process of reclaiming is fully demonstrated and the simplicity of the system is manifest.

Beecroft & Partners, Limited.

This well-known firm of consulting foundry and analytical chemists, of St. Peter's Close, Sheffield, and at Norfolk House, 35, Cannon Street, Birmingham, show a number of foundry specialities, which they have developed in their own laboratories and experimental foundry. They include the following:—

Ladle Flux.—This material is used for desulphurising iron in the ladle. The life of the ladle is lengthened by making the slag more fusible.

Beecroft's Sandoil is used for making silica sand cores. It gives no offensive smell and resists moisture.

Corbeerite Binder.—This liquid is used with red sands, burnt sands, etc., and for mixing in blacking wash to prevent "washing off."

Corbeerite Powder.—This material is used for non-ferrous and intricate core work.

Brass Flux, Aluminium Flux, Beecroft's No. 101 Powder, Ceylon Plumbago, Moulders' Special Blacking, and Beecroft's Parting Powder are also exhibited.

The Vono Company.

The Vono Company, of Duport Foundry, Dudley Port, Staffs., confine their exhibit to vices. Altogether some twelve types are shown, and being a foundry concern, they have developed and designed special vices for the moulder, the fettler, and pattern-maker. They are made from semi-steel cast iron.

REPLYING TO A QUESTION in the Melbourne House of Representatives as to whether, in dealing with tenders for copper wire, the Tender Board granted preference to Australian wire beyond the amount of the tariff, the Postmaster-General said that the Tender Board was not instructed to grant any preference above the tariff, but where the Australian article was tendered for at a higher price than the outside tender, plus duty, the matter received Ministerial consideration. The Postmaster-General added that the amount of Australian copper wire purchased in 1922-23 and 1923-24 was 6,900 tons, at an average price in 1922-23 of £126 11s. a ton, and in 1923-24 of £108 11s. per ton. The average price per ton of the lowest British tenders, free of duty, was £96 8s. in 1922-23, and £83 18s. in 1923-24. The duty on British wire was 30 per cent., and the added cost to the department through the purchase of Australian wire in preference to British was £114,700 in 1922-23 and £74,700 in 1923-24

The Technical Side of Oil-Sand Cores.*

By C. W. H. Holmes, M.Met.

I.—INTRODUCTORY.

It was the writer's original intention to prepare a somewhat complete Paper dealing with the production and use of oil-sand cores, in which not only would the fundamental principles have been explained, but the results of practical tests would also have been included to support or to refute the various conflicting statements which have occurred in the technical Press regarding oil-sand core production.

Unfortunately this has not been possible, and, as the result, the Paper has been divided into two parts, the first of which deals with the principles and practice of the subject, and is presented for discussion at this meeting. The second part will consist of data collected in the foundry and the laboratory, and will be prepared when the writer has more time at his disposal.

The particular object of this Paper, or at least, this part of it, is to explain the "reason why" to the practical foundryman, and thus help towards an understanding of a few of the many problems which are met in this branch of foundry work.

It has been the writer's experience that attempts to introduce oil-sand cores into a foundry either result in success or rather dismal failure, and it may be well to state that whilst such a failure may be due to the core oil, or the sand, or the baking equipment, or to oneself, the fact remains that by careful thought and investigation the failure is most certainly traceable to one or the other. There is no magic about oil-sand cores.

Given suitable core-baking equipment, every foundryman should be able to make oil-sand cores successfully, and the problem then ceases to be a technical one and becomes a commercial one.

Will it pay? This is the question which each foundryman must decide for himself. Generally speaking, when loam or dry-sand cores are replaced by oil-sand cores, the increased cost of core-making materials (and possibly tackle) is more than covered by the decrease in labour costs, both on the core-bench and on the fettling floor, and by the decreased percentage of defective castings.

The second question which must be faced is: Is it practicable? There are some cases in which the use of oil-sand cores is unwise, but such cases will be discussed at a later stage of the Paper.

II.—THE SAND.

The selection of a suitable sand is equally as important as the selection of a suitable core-oil, and it may be of interest to note that whilst the really unsuitable core-oil is usually taken off the market as the result of lack of business, the unsuitable sand is always with us. It is often, perhaps, close at hand, and the price may be tempting, but the practical difficulties that lie in the way of improving unsuitable sands by mixing, grinding, sieving or washing are so great as to be uneconomical. It is very difficult to improve an unsuitable sand, but it is remarkably easy to spoil a good one.

What, then, is a good sand? Obviously it is the sand that produces successful cores. Why do cores made from some sands produce blown castings? Why are cores weak and friable when made with certain sands? Why has a properly-made oil-sand core such excellent venting properties? These are practical questions, and an attempt will be made to answer them and others as simply as possible.

So far as the general run of grey iron castings is concerned, the chemical analysis of the sand is a factor of so little importance that we need not consider it, but for heavy iron castings and for steel castings it is important that the sand should be refractory: if it is not, the castings will be dirty and fettling costs will be excessive.

Broadly speaking, then, sea sand or river sand or dune sand is used for core making in the iron foundry and silica sand for core making in the steel foundry.

But there are great differences between one sea sand and another, not only in the unimportant matter of chemical analysis, but also in the vitally important matter of mechanical analysis (or, to put it more simply, size of grain).

If a glass jar that will just hold one pint is taken and filled to the brim with marbles, it will be found (provided that the marbles are all the same size) that one is still able to pour into the jar between one-quarter and half-a-pint of water. Now, if we consider these marbles to be the grains of sand in a core, highly magnified, we see that there are considerable spaces between the grains along which the gases generated by the heat of the metal can travel; and so long as the particles are rounded *and of regular size*, it does not matter how big or how small they are, we shall still be able to find the same high proportion of spaces.

For instance, if we take another pint jar and fill it to the brim with No. 5 lead shot, we shall still be able to pour into the spaces between the shot as much water as we could in the case of the marbles.

But if we take a third jar, and, having filled it with marbles, we run in lead shot or other fine material between the marbles, we shall find that we cannot run in nearly so much water as we could in either of the previous cases. These simple experiments show that, if it is thought desirable (as, of course, it is) to have the maximum amount of spaces in a core for the gases to escape through, there must be used a sand of regular grain size. The importance of regularity of grain size is especially important in the case of fine-grained sands, for this reason.

Take the case of two sands—a coarse one with grains $\frac{1}{30}$ in. diameter and a fine one with grains $\frac{1}{60}$ in. diameter; gases escaping from a core made from the fine sand will have greater frictional resistance to overcome, because not only are the spaces between the grains narrower, but there are twice as many turnings and twistings round the grains than in the coarse sand. Hence a small amount of very fine material might not matter in the coarse sand, but added to the already greater frictional resistance in the finer sand, it might cause trouble through blown castings.

The tabulated results of this explanation may be clearer:—

Type of sand.	Air spaces %.	Frictional resistance.	Venting properties.
Coarse regular grain ..	High	Low	Best
Fine " " ..	High	High	Good
Irregular grain ..	Low	High	Bad

There are several reasons why coarse sands have their drawbacks as well as their advantages. They do not give such a good skin as finer sands to the casting, neither are cores made from them easy to handle when much rubbing down has to be done, as, for instance, when a core is made as a simple block and is radiused off after baking.

Further, when using coarse sands, the weakness of the core in the green state is accentuated, because its strength in the green state depends on the number of contacts between the grains per square inch (for it is only where the grains touch that they can be held together). Obviously the finer the sand, the greater the number of grains, and hence the number of grain contacts per sq. in. of core section.

Reference to Table I will make this clear; it must be borne in mind, however, that these figures are only approximate.

TABLE I.—*Grain Size and Contact Points of Sands.*

Grain Size.	30 mesh.	60 mesh.	90 mesh.	120 mesh.
Grains per cub. in. ..	240,000	2,000,000	6,600,000	16,000,000
Contacts per sq. in. ..	8,000	32,000	72,000	130,000

This weakness, encountered when using coarse sands, is very strongly marked when the sand is not dried, or at any rate, when it is appreciably damp, before mixing with the core-oil and water; the core is "heavy" and falls readily.

* A Paper presented to the Newcastle Conference of the Institute of British Foundrymen.

Table II shows the mechanical analysis of the sand used by the writer for general work. For very large cores, the sand might be somewhat coarser, although no difficulty has been experienced as regards the venting properties; for small delicate work, such as automobile jacket cores and the like, a finer sand would be preferable.

TABLE II.—*Mechanical Analyses of Sea Sand. (A) Metric Grading (Round hole Sieves); (B) English Grading (Square Mesh Sieves).*

Grade.	(A) Grade Size.	(A) Per cent.	(B) Grade Size.	(B) Per cent.
Coarse sand ..	1.0 —0.5 mm.	nil	On 30 mesh	nil
Medium ,, ..	0.5 —0.25 ,,	7.60	30—60	1.50
Fine ,,	0.25—0.10 ,,	91.20	60—90	58.50
Coarse Silt	0.10—0.05 ,,	1.00	90—120	36.70
Fine ,, ..	0.05—0.01 ,,	0.20	Through 120	3.30
Clay	0.01	nil	—	—

It will be noticed that the regularity of grain size is very marked.

This particular sand is a sea-sand, and although it answers its purpose excellently a wind blown or dune-sand is preferable to a sea-sand or river-sand.

This is due to the fact that the friction between the grains as they move over each other in air is greater than in water; hence the wind-blown grains lose their sharp corners and become rounded more readily than the water-worn grains.

Rounded grains give better venting properties than angular grains, although general opinion is to the contrary; this error is probably due to the incorrect use, in the foundry, of the term "sharp," which, as generally used, means "coarse and free from clayey matter."

A number of so-called "sharp" sands have well-rounded grains.

If the term "oil-sand" is used to denote a mixture of sand with a binding agent, the basis of which is linseed or a similar drying oil, then it is important that the sand should be "clean," that is, it should be free from clayey matter. In the case of such binders as resins, gums or similar proprietary materials, this is not so important.

Mixtures of naturally-bonded sands and core-oil can be baked to make more or less successful cores, and such mixtures have the great advantage of being strong in the green state. This type of core, however, requires more oil than would be used with a clean sand; has a tendency to be soft inside, and, in consequence of the extra oil content and poorer venting properties, is more liable to blow. Also, they are not so easy to remove from the casting.

The explanation as to why "dirty" or naturally bonded sands require more oil than clean sands will be given in the section dealing with the mixing of oil and sand in order to avoid repetition.

The old sand from the fettling-floor may be used again in proportions varying with the intricacy of the core; but great care should be taken to avoid the mixing of old loam cores or similar fine material with the burnt oil sand, as this may (probably will) choke the natural vent in the oil-sand cores and result in blown castings. The old sand, with its coating of soot, appears to cause less trouble than clayey sands, as regards core-oil consumption.

Nothing has been said, so far, regarding the use of silica sands, but the foregoing statements apply in general to sea, river, dune or silica sands.

It remains, however, to warn those who propose to mix sea or river sand with silica sand that both sands should have similar sized grains if the best venting properties are to be obtained.

Speaking generally, the chances of improving the venting properties of any sand by mixing it with another are very small. On the other hand it is quite easy to produce any number of mixtures from two sands, each having inferior venting properties to either of the original sands.

Finally, the ideal sand for oil-sand cores will be briefly considered:—

It must be more or less refractory, according to the class of casting to be made, it must be of uniform grain size, and it should be free from clayey material or organic matter.

III.—THE OIL.

Core oils consist essentially of vegetable oils which have the property of becoming sticky, and ultimately hard, when exposed to the air. This group of vegetable oils is known as the "Drying Oils," and linseed oil is the best known and most commonly used member of the group.

In practice, the linseed oil is usually heated or "boiled" together with gums or resins to increase its binding properties.

Subsequently to this, mineral oils may be added to reduce the viscosity of the mixture, and make it easier to handle.

The following combination of properties is desirable in a good core-oil:—

(1) It must be moisture-proof; (2) it must have sufficient strength when green to enable the cores to be handled; (3) it must not stick to the core boxes; (4) the viscosity must be low enough to enable it to mix easily with the sand; (5) the fumes given off on heating the cores must not be poisonous or objectionable; (6) it must have a high "film value," which in plain language means that it must have the property of binding a large amount of sand together; (7) the rate of oxidation must be such that whilst the core takes readily, yet it does not become sticky and crumble on the core-bench; (8) the physical properties of the oil must be such that the oil is not easily drawn to the surface of the core whilst baking, and this property is fairly common with gum binders, and results in a core with a hard skin and a soft centre, which, if rubbed down, is fragile and washes readily; (9) the core must stand up against a reasonable wash of metal; and (10) after casting the core should crumble readily, and the sand run from the casting freely.

Generally speaking, any core oil will possess one or more of these properties in a marked degree; some core-oils are excellent productions, having many good points; others are not.

It is most regrettable that during the last few years almost every firm connected either with the oil trade or with the foundry industry has seen fit to add yet another to the already long list of core-oils.

And it is also certain that many of them have neither the requisite equipment nor the detailed knowledge of foundry work required in the manufacture of a satisfactory core-oil.

The cost of a core-oil should not be confused with the price per gallon; the true cost should be based on some unit quantity, say, 100 or one hundredweight of good cores.

IV.—THE PREPARATION OF THE CORE MIXTURE.

To obtain the most economical and the most satisfactory results, and to obtain regularity in the mixture from day to day, the core mixture should be prepared with great care. The preparation should be divided into two stages; first the mixing of the core-oil with the water, and second the incorporation of this mixture with the sand.

The core-oil and water should be mixed in the required proportions, usually varying from one of water to one of oil, to three of water to one of oil, and then vigorously agitated so as to form an "emulsion."

This emulsion consists of a very intimate mixture of very small globules of oil in water, and may be readily prepared, either as a matter of interest or for use in the foundry in small quantities, by shaking equal parts of core-oil and water in a bottle. The bottle should not be more than two-thirds full, and should be shaken vigorously for about a minute; the bottle will then be seen to contain a yellow creamy liquid consisting of emulsified oil and water. In practice emulsification is best carried out by turning a jet of compressed air into a mixture of core-oil and water.

On standing, these emulsions usually separate out more or less completely into two layers of oil and water, and should be re-made just before they are required for use.

Before proceeding to discuss the method of mixing this emulsion with the sand it is advisable to consider briefly what has to be accomplished, and why.

If there is a heap of sand which has to be moistened uniformly—and it is essential in foundry work that sand for any purpose should be uniformly moistened—there are two factors which

must be taken into account—the character of the liquid and the quantity to be used.

It has already been shown in discussing the core-oil that it is difficult to mix stiff, viscous liquids satisfactorily with sand, and, again, the liquid must not only be fluid, but must have the property of easily wetting the sand grains; in other words, the "surface tension" between the sand and liquid must be low.

Further, the smaller the amount of liquid, generally speaking, the more difficult it is to obtain a homogeneous mixture.

From this it is seen how the emulsion helps; instead of trying to mix oil with water and to coat the mixture around the grains of sand in one operation, oil and water have been mixed under the best conditions, and have as the result a larger volume of liquid which has good mixing qualities.

The ideal mixture consists, of course, of the thinnest possible coating of emulsion, uniformly spread around each and every grain of sand, that will give the requisite strength in the finished core.

Some idea of the area to be covered by the oil in 1 cwt. of sand and the thickness, or rather the thinness, of the oil coating may be gathered from Table III.

TABLE III.—*Surface to be covered with Oil in 1 Cwt. of Sand.*

Grade.	30	60	90	120
Total surface (sq. ft.) in 1 cwt. sand	3,150	5,670	9,100	13,740
Thickness of oil film (ins.) using 1 : 40 of oil	0.00011	0.000058	0.000033	0.000025

As a matter of fact, so soon as mixing ceases and the grains of sand are at rest the liquid coating is no longer uniformly spread over the grains; it is drawn towards the points of contact between the grains where, of course, it is required.

However, if the foundryman succeeds in spreading the coating uniformly the natural force known as "surface tension" will look after the drawing up of the liquid to the grain contacts without further assistance.

Methods of Mixing Sand and Oil.

Turning now to the methods available for mixing the emulsion and the sand with a view to obtaining the ideal mixing described above, any of the following methods can be used:—(1) Hand mixing; (2) mechanical riddle; (3) pan mill; (4) centrifugal mixer; and (5) paddle mixer.

Method (1) is fairly good if care is taken; it is, of course, costly where much sand has to be mixed, and the oil content of the mixture cannot be cut down to a minimum where this method is employed. The mixture is also likely to vary from day to day, and if viscous binders are used is liable to be heterogeneous, causing washes and scabs.

Method (2) is slightly better than (1), but mechanical riddles, like hand riddles, are of little use for anything except removing stones and scrap.

Method (3) is not advisable, primarily because there is more than a risk of grinding the sand and thus impairing the venting properties; secondly, very few foundries can keep a pan mill solely for mixing oil-sand, whilst if this is not done either some clayey material is picked up from the mill or else a man has to clean it; and the cleaning of the average pan mill, being a lengthy matter, costs money.

Method (4), like method (3), has been tried by the writer, and is fairly successful after a preliminary hand mixing. It does not, however, seem to be an ideal method, especially when old sand is used in the mixture, as the old sand contains many grains which have been cracked by the heat of previous casts, and are liable to be broken up in the centrifugal mixer. Sand grains are certainly cracked by heat, and the writer has shown elsewhere* that centrifugal mixing does break up the sand slightly, but in this particular connection no data are to hand. The suggestion is put forward only as a probability. Centrifugal mixers tend to become choked by the core mixture drying around the steel studs with repeated use.

Method (5), provided that the paddle mill is designed to give a kneading or spreading action to the sand, presents advantages over any of the four previous methods; it tends towards perfect and rapid distribution of the oil (or emulsion). Hence it is probable that less oil can be used to give as good results as were previously obtained by hand mixing; there is no chance of grinding up the sand grains as in the pan mill or centrifugal mixer; and the labour required consists simply in loading and unloading the mixer.

Wherever the output of oil-sand cores is considerable, the paddle mixer will prove to be the most efficient and economical machine.

Should Sand be Dried before Mixing.

The subject of mixing cannot be dismissed without reference to the somewhat vexed topic concerning the use of dried sand or moist sand.

Whilst it would appear at first sight to be rather foolish to dry sand and then moisten it again, yet there is a great deal to be said for this practice.

Leaving out of the question sand received in such a wet state that it contains more moisture than is desired in the core-mixture (for such sand will usually cost more in wasted time and materials than it would cost to dry it), it will be considered why one should, or should not, dry the sand.

The principal argument in favour of not drying the sand is that it is less trouble.

So it is, on the face of it, but when examined more closely it is found that a bucketful, or a barrowful, or a mixer full, or whatever measure is used, of dry sand contains more grains of sand than it does of wet sand.

This may not sound convincing, but it can be proved by anyone who cares to fill a bucket with wet sea sand, shake it down by bumping the bucket on the floor, put it in the stove until it is thoroughly dry, and then bump it on the floor again.

The bucket will no longer be full of sand, but probably somewhere about three-quarters full.

So that there is not the same amount of sand in a bucket of wet sand as in a bucket of dry sand; there is less surface, and hence require less oil to coat it with. It follows that if one is using sand in the raw state one is either using an excess of oil as an insurance against the sand being drier than usual, or is running the risk of having a batch of weak cores.

To ensure economy in oil consumption and to ensure regularity in the core-shop product from day to day, it is better practice to pre-dry the sand.

V.—THE BAKING OF OIL-SAND CORES.

Strictly speaking, oil-sand cores are baked rather than dried; as will be explained later, there is more in the process than simple evaporation.

It would be much easier to write a book on the baking of oil-sand cores, dealing with the process completely, than to attempt to compress an explanation of the process into a few lines.

Suppose that there is a ton of oil-sand cores, containing 5 per cent. of moisture and 1 per cent. of oil by weight: there is a hundredweight of water to heat up to its boiling point, to evaporate, and over and above this, there has to be supplied the energy required to lift this weight of water vapour out of the stove.

As a matter of fact the whole of this water could be evaporated without heating the stove up to boiling point (212 deg. F.). It could be done by taking advantage of the fact that air at all temperatures will hold a certain amount of moisture, and the hotter the air the more moisture it can contain.

But as a cubic foot of air below 212 deg. F. (100 deg. C.) can only contain a comparatively small amount of moisture, one would have to pass such an enormous number of cubic feet of warm air through the stove that the time taken and the fuel consumed would be excessive.

This method of moisture evaporation operates to some extent whilst the stove is heating up, but as has been pointed out, it is not economical to have a larger volume of air than is necessary to heat up the stove passing through at this period.

* "J.I.S.I." 1922. No. 2. An Investigation on the Factors Influencing the Grain and Bond in Moulding Sands.

When the stove has reached a temperature of 212 deg. F. (100 deg. C.) a new set of circumstances arise. The water is now rapidly evaporated, and occupies a very great volume; the hundredweight of water from the ton of cores will occupy 3,000 cub. ft. when completely evaporated; enough to fill a stove 30 ft. × 10 ft. × 10 ft.

But as it requires, roughly, five and a half times as much heat to evaporate the water in the cores as it does to heat the same amount of water from the cold state up to boiling point, there is a rather heavy demand for heat at this period, and the stove temperature rises very slowly, especially if it is well filled with cores.

During this period in the heating of the stove there is a tendency for the moisture to be evaporated at one part of the stove and then become slightly cooled and condense to a heavy fog, which falls to the bottom of the stove.

(This can be observed in many old-fashioned, natural-draught, stoves, especially if the door is lifted a fraction of an inch to admit cold air to the floor.)

In the writer's opinion it is this stage, in the drying of cores generally, that has led to the many heated controversies which have raged around the question as to whether the exhaust flues should be at the top or at the bottom of the stove. The "fog" is so heavy that it requires a considerable amount of energy in the form of draught to lift it, whilst it is difficult to evaporate, because often only the top surface of the "fog" comes in contact with the heat.

This matter will be referred to later in connection with stove design.

Sooner or later the bulk of the moisture is evaporated, and the temperature of the stove rises to such an extent that further condensation cannot take place; under suitable conditions the remaining moisture is then easily evaporated.

If at this stage an oil-sand core is removed from the stove it is apparent that it has stiffened considerably, but it is still soft and sticky, and quite unlike the desired product; it has been dried, but not baked; the physical change of evaporation has taken place, but the chemical change of oxidation of the core-oil has hardly started.

In order that this chemical change shall take place with sufficient rapidity for commercial requirements, the heat must be raised to a temperature varying between 350 deg. F. and 500 deg. F. (176 deg. C. and 260 deg. C.).

The intricate chemical changes taking place under these conditions cannot be discussed here, but the oil is gradually converted into a hard, resin-like body, and at the same time absorbs about one-fifth of its weight of oxygen.

This oxygen can only be supplied by atmospheric air, hence we see that if the cores are to be baked hard and strong, the "foggy" atmosphere (which cannot supply the oxygen) must be replaced, not by burnt air which has passed through a coke fire, but by hot, unburnt air which has passed either over or round the fire.

In practice, the oil is not completely oxidised, the absolute completion being a slow and unnecessary procedure; what should happen is that the oil should be nearly completely oxidised to give the core strength, and then the resultant resinous bodies should be still further heated until they begin to be slightly charred. By this means is produced a core which has almost the maximum strength, coupled with the minimum gas content.

As a result of this brief survey it is seen that the baking of an oil-sand core may be divided into five stages:—(1) Heating up and slight evaporation; (2) moisture evaporation; (3) heating up the dried core; (4) oxidation of the core-oil; and (5) slight charring of the resultant resin.

Choice of Stoves.

The simple natural-draught stove, with a door at one end and a firebox at the other, leaves much to be desired, both as regards control and fuel economy when drying cores, especially oil-sand cores.

A stove working under forced draught with either:—(*a*) A sole flue, ensuring a hot floor, or (*b*) a large flue area at floor level, and a hot chimney stack to lift the moisture out of the stove, is what is required.

The flue arrangements should be such that air can be passed over or through the fire at will, so that hot free oxygen can be supplied to the cores when desired and so that the temperature can be quickly raised, when required, by blowing air through the fire.

The core oven may be heated by coke, gas, oil or electricity, each fuel having its own advantages and disadvantages.

Temperature control, with gas or oil, is easily effected, but, generally speaking, cost of fuel per hundredweight of cores baked is in excess of coke when burnt in a modern stove. It must also be remembered that with town's gas or oil, the combustion of the hydrogen results in a high moisture content in the hot gases; this moisture may condense in a cold stove and have to be re-evaporated subsequently. The gases from the combustion of coke, on the other hand, contain only a negligible amount of moisture.

Apart from the cost of current, which in the majority of cases is prohibitive, electric core baking has distinct points in its favour. It is clean and under complete control; it is essential, however, to provide some means for exhausting the moist air from the stove during the drying period and circulating hot fresh air during the oxidation period.

Personally, the writer is in favour of a coke-fired stove working under forced draught, and so arranged that the air can be passed either through or over the fuel bed.

The principal exhaust flues should be under the floor of the stove, and the flues should be so arranged that hot gases may be by-passed from firebox to chimney stack, so that this may be heated and capable of lifting the moist gases from the exhaust flues.

VI.—THE FINISHED CORE.

The finished core consists essentially of sand grains, a resinous bond, and air spaces. When properly made and baked, an oil-sand core combines high strength with maximum permeability, or, in practical terms, very good venting properties. Provided that a good oil has been used, the core will also have the added advantages of requiring less core-irons, whilst it will not absorb moisture from the mould; this is a highly important point where light intricate castings are moulded in green sand.

Now, before considering the effect of the heat of the molten metal upon the core, it may be of assistance to consider the reason why oil-sand cores are less liable than the general run of cores to produce blown castings, together with the principles underlying "core-blows."

When molten metal is run around a core—any kind of core—the air in the core expands at once and seeks an outlet; at the same time, any moisture in the core is converted into steam, and in doing so expands considerably, whilst simultaneously the binder, whether clay in a dry-sand core or resin in an oil-sand core, decomposes and generates gas.

This generation of gas commences at the surface of the core and extends inwards as the heat penetrates to the centre. It naturally creates a greater pressure in the core than the external pressure of the atmosphere, and the gases seek an outlet. Two outlets are available: the first is through the air spaces between the grains of sand, possibly into an artificial vent and out into the air at the print end of the core; the other outlet, as is well known, being through the metal. This latter course may result in a blown casting or it may not; as a matter of fact, far more cores blow than many foundrymen care to believe, but owing to the fact that *hot* molten cast iron is an accommodating sort of metal with a considerable range of fluidity or semi-fluidity, it often remains molten until after the blow has subsided, and a sound casting results.

Should anyone doubt the above statement, let them cast a few of their moulds fully cored up but leaving off the copes; a dry-sand core of large bulk in relation to the area of the prints should be chosen for preference, and the mould should be slowly filled, so that the various stages may be more closely watched. The determining factors as to whether the gases will travel through the core or through the metal are these:—(1) The volume of gases generated at any time; (2) the resistance offered by the core to the flow of these

gases; and (3) the head of molten metal above the core.

Now, the molten metal exerts a pressure of 4 ozs. per sq. in. for each inch of depth, so that if there is a core with half an inch of molten metal above it, the back pressure of the gas in the core has only to exceed 2 ozs. per sq. in. pressure to lift the metal and blow through it. If the height of metal above the core were six inches, the pressure inside the core could rise to 1.5 lbs. per sq. in. before trouble occurred.

However, the height of metal above the core is often either beyond normal control or expensive to control, so that foundrymen should turn their attention rather to the production of cores that will generate as little gas as possible together with the best possible venting properties, so as to allow this gas to escape. As has been explained, the properly-made oil-sand core combines these properties in a marked degree.

Turning now to the influence of heat upon the core, the progress of the core from the weak green condition to the strong state after baking, in which the grains are securely held together by a strong resinous substance, has already been detailed. This resinous bond breaks down when it is heated by the molten metal into water vapour; a mixture of gases containing carbon; a residue consisting mainly of carbon, and a certain amount of soot produced by the decomposition of some of the gases.

Several things will be noticed on watching metal cast around an oil-sand core; in the first place, at the moment the vent fires the flame will be blue, but will change rapidly to a white, smokey flame. The blue flame denotes complete combustion, the air for which is provided by that existing in the pores of the core; so soon as this is exhausted, the white, smokey flame appears, denoting that the pores of the core are now filled with escaping gas.

Another interesting fact is that oil-sand cores may, in many cases, be used without having been blacked and yet the casting shows a good skin; whereas, had a dry-sand core been used under similar circumstances, it would almost certainly have burnt-on. The reason for this lies in the fact that the residue from the oil behaves something after the manner of coal dust; it evolves tarry matter and gases which are known as "unsaturated hydro-carbons"; these bodies break up under the intense heat of the metal and deposit soot (a form of carbon), which not only acts as a lubricant to the flow of metal on the core face, but also acts as a splendid refractory material, preventing the burning on of sand to sand or sand to metal.

Very few people appear to appreciate the important service which carbon performs in the two functions described above.

Conclusions.

When the sand is removed from the casting during fettling it is seen that it is black owing to deposited soot and the carbonaceous residue; if, however, the projecting print end of a core, where the gases have ignited as they escaped from the vent, is examined it is seen that the grains are no longer black, but white. The carbon coating (almost inconceivably thin) has been burnt off, and the sand has reverted to its original condition.

Having traced the sand and the oil from the beginning to the end of the cycle, little remains to be said, and it is the writer's wish that his explanations have been lucid and efficient; there are, however, one or two practical points which might be usefully dealt with before concluding.

It is commonly believed by those who have not attempted it that oil-sand cores cannot be used successfully in heavy castings; this is *not* the case, however, as the writer has castings in the floor at the moment of writing 3 tons in weight, and completely cored-out with oil-sand cores.

There is, however, a limit, and this limit is reached when the resinous bond in the core is burnt out before the metal has solidified. When this occurs, the core is either distorted to a more or less shapeless mass by the pressure of the metal or crumbles and floats up under the cope. When it is borne in mind that each foot in the height of the molten metal exerts a pressure of 3 lbs. per sq. in., it is obviously unwise to set a core with any chance of crumbling at the bottom of a deep mould unless the metal thicknesses are so small as to permit of rapid setting of the metal.

When working close to this limit, it is important that the cores must not be over-baked.

At the other end of the scale is the case of the light casting containing a bulky core. Here there may not be sufficient heat given out during the cooling of the metal to break down the resinous bond, and the writer has seen cases where the centres of such cores were extremely hard and difficult to remove.

In such cases, where the core is practically surrounded by the metal, ashes may be used to fill in the centre, whilst if a large flat print surface is available it is sometimes possible to fill the centre with moist sea sand, which, after holding up the core during baking, falls out readily and leaves a more or less shell-like core.

When this type of problem is encountered it is advisable slightly to overbake the cores, as they are then rendered friable more easily by the limited heat available from the casting.

Steel Shot Cores.

The writer has developed and patented a modification of the usual oil-sand core, the sand being replaced by fine steel shot.

Whilst this type of core is more difficult to make than the usual type of core, and is too costly to use indiscriminately, yet it has proved its utility in places where solid denseners or chills could not be employed owing to the impossibility of extracting them from the finished casting.

In one particular casting the frequently occurring blow-holes, once attributed vaguely to "bad metal," have entirely disappeared since oil-shot cores were used in its production.

Which fact seems to indicate that there is still something to be learnt, both about "bad metal" and good cores.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

A Name Confusion.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—We have been inundated by so many inquiries from all parts of the country respecting the notice which has appeared in the Press in regard to the proposed winding-up of Harper Bean, Limited, that we crave the indulgence of your columns for the publication of the following facts.

This Company (A. Harper, Sons & Bean, Limited), the manufacturers of the "Bean" car, is an old established concern founded in 1826; it is a private company within the meaning of the Companies Acts, and its shares are not, and cannot be, quoted in the Stock Exchange Official List.

It is totally different from and must not be confused with Harper Bean, Limited, which is a financial company, formed at the end of the year 1919, and is not in any way a manufacturing concern.

In these circumstances we wish to assure the public that the proposed liquidation of Harper, Bean, Limited, if decided upon, will not affect either the financial position or the activities of A. Harper, Sons & Bean, Limited.—Yours, etc.,

A. HARPER, SONS & BEAN, LIMITED.
H. J. CADDICK,
Secretary.

Dudley, Worcs.,
June 20, 1924.

AT THE CONVENTION of the district engineer representatives attached to the Feed Water Specialists Company, held in Liverpool from June 10 to 13, the annual dinner took the form of a send-off to the manager, Mr. H. W. Bannister, who is now on a voyage to the United States on a mission from which further valuable data for securing economies in steam raising is to be obtained. Mr. W. H. Crowe, of the Andrew Maxwell Company, in expressing the good wishes of the assembly, referred to the appreciation of steam users of the research in colloidal chemistry carried out by the laboratory staff under the direction of Mr. Bannister.

Discussion of the Newcastle Convention Papers.

THE FORMATION OF GRAPHITE.

By L. NORTHCOTT, M.Sc.

Heat Treatment and the Production of Pearlitic Structure.

MR. J. SHAW congratulated the author upon the work he had carried out and the results obtained. Discussing the first part of the Paper, he asked what was the section of the annealing specimens. Would the annealing effect on comparatively large sections—say 3 in. sq.—be the same all through as sample 8, Table I. In this case the temperature was 1,050 deg. C., the annealing time was 17½ hours, and the micro-constituents were given as graphite, pearlite and ferrite. It would be interesting to learn whether the author had annealed comparatively large sections of white cast iron and obtained a pearlitic structure all through the piece.

Precipitation of Graphite After Attaining Equilibrium.

In regard to Part II of the Paper. Frankly he could not reconcile the results obtained in one table with those given in the other tables. They were told in one case that equilibrium was attained at the end of 10 mins., and when the heat treatment was continued for 30 mins. practically no further graphite was obtained. Where they to understand from this that if a casting was held at a given temperature, above the change point, after a time no further graphite was formed. Casting temperature plays a part in the amount of graphite formed, yet no casting temperature is given in Tables II, III or IV. Mr. Shaw also pointed out that the time taken to reduce the temperature in the muffle from 940 to 700 deg. C. in Table II is not given. The same fact applies to Tables III and IV, so it is difficult to form conclusions. But Bars A2, B1, and F4 all quenched at 900 deg. C., yet 1.7, 2.42 and 1.90 per cent. graphite respectively are obtained. Again, B3 and F2. In the first case 1.94 per cent. graphite was thrown out, while in the latter only 1.6 per cent. was obtained, yet both these latter must have been held over the 10 mins.—mentioned as the time to obtain equilibrium at 1,000 deg. C.

Free Graphite in Molten Iron.

As to the vexed question of whether graphite could exist in the free state in the molten metal, the fact pointed out by Mr. Northcott that in the quenched specimen, G1, in Table VI, it was possible to obtain 0.27 graphite in the very short time it took to solidify this specimen, gave a reason for some of things encountered that was considered proof that free carbon was present in molten iron. At the same time, it was quite possible that pouring a very thin stream of molten metal into water any free carbon might be washed away in the water. The figures given in Table VIII were in contradiction with those of Hailstones in his Paper before the Iron and Steel Institute. Hailstones stated that when casting at 1,428 deg. C. with the metal he used, the graphite was 2.83 deg. C. He cast fresh bars at intervals of 2 mins. The last bar was cast at 1,264 deg. C., at which temperature his graphite carbon content was increased to 3.126 per cent. Which result was to be considered correct?

Decarburisation Danger.

MR. NORTHCOTT, replying to Mr. Shaw, said that the specimens he had annealed for the first part of the Paper were not more than 1 cm. square. His chief trouble with sections of such small size was that decarburisation took place on the outside. That was why they had been annealed in a partial vacuum. On the small specimens, or, for that matter, on big ones, if they were annealed for a sufficiently long time, particularly in an oxidising atmosphere, decarburisation would take place. With regard to pearlite, he certainly thought in white heart metal with high sulphur or chromium they would get a matrix of pearlite with nodules of temper-carbon. As to Mr. Shaw's remarks with regard to Tables II and III, it must be understood that those were not intended to be equilibrium conditions. In Table V there were inequilibrium conditions, and it was seen that after about 10 minutes at a temperature of 1,000 deg. equilibrium was attained. He could certainly say that at any temperature above 700 deg. there was only one carbon content when the metal was in equilibrium. In this case it was about 2.2 per cent. at 1,000 deg.

A SPEAKER asked how Mr. Northcott accounted for the difference in graphitic content between specimens A2 and B6 in Tables II and III; the temperature was the same in each case, and each was held for 10 minutes.

MR. NORTHCOTT replied with the aid of a sketch of the iron-carbon equilibrium diagram. His figures in Tables II and III were distinctly not in equilibrium. If these irons had been held at each temperature for at least 10 minutes he believed Mr. Shaw would see that the figures would have been equal in both tables, but with a descending temperature—the cooling was fairly rapid in a small gas muffle—equilibrium conditions had not been obtained. With regard to molten metal, he had no doubt that carbon in molten iron did not exist as graphite. He could not prove that very well at the moment, but if they made the experiment—not an original experiment—of pouring molten iron into a bucket of water, and then taking a small piece of it and dissolving up in acid, there would be no graphite there at all. He had heard it said that graphite was there in the colloidal state, but if they did not find graphite in the analysis they could be quite sure that graphite was not there at all. He doubted very much if any graphite would be washed away by the water.

Comparison of Brinell Results.

MR. SIMCOX said he could testify that the author had entered into his work in a thoroughly efficient manner. With regard to Graph V, he asked if Mr Northcott could explain the difference in the dotted curve for the edge, giving a Brinell value of 138, as compared with the others. The top curve, for the centre, agreed very well with the view that with increase of graphite there was a corresponding decrease in hardness, which one could quite understand, or, at least, one would expect. But in the curve for the edge there was a dip near the end. Was that due to the idiosyncrasies of cast iron? Mr. Northcott in his experiments had used a 1 mm. ball in one case and a 10 mm. ball in another. Could they interpret the results from the 1 mm. ball into the results of the 10 mm. ball? In dealing with malleable iron on several occasions he had met a hard constituent, which usually occurred round the grain boundaries. Dr. Hatfield had mentioned it in his book on "Cast Iron in the Light of Recent Research." It appeared that there was some doubt about this substance, and he would appreciate further information concerning it.

MR. NORTHCOTT, referring to Mr. Simcox's remarks as to Graph V, said he was glad Mr. Simcox had been able to find sufficient excuse for the dip in the curve for the edge in putting it down to the idiosyncrasies of cast iron. There was no doubt that that was so, but he had put it down to the large size of graphite flakes in that particular specimen. Why that should be so he did not know. With regard to the 1 mm. and the 10 mm. ball, he was afraid that the results were not consistent. The two instruments at his disposal did not give exactly the same values, so that the top hardness curve for the centre should certainly come down considerably. With regard to the point raised as to malleable iron, he should imagine that the constituent to which Mr. Simcox had referred was cementite. Although in good malleable iron there should be no free cementite at all, in some castings there were considerable areas of cementite round the boundaries. That was shown in Figs. 11, 12 and 13 of the Paper. The sample cooled far too quickly. It was the general practice to occupy at least two days for cooling down from a high temperature in commercial work, and he could only

imagine that that practice was not followed in cases where there were free cementite areas in the irons.

Chilled Malleable Iron and Annealing.

MR. F. J. COOK said that in regard to the formation of graphite or temper-carbon in malleable iron castings during annealing there was a difference in cases where the malleable iron had been chilled in manufacture as compared with other cases. In certain parts chills had to be used in order to produce sound castings, and it would be worth noting in future investigations what effect that had on the size, condition and formation of the graphite during annealing. Another important point was that which was mentioned in No. 7 of the author's conclusions, *i.e.*, the formation of the graphite in curvey flakes. When examined under a microscope, a curvey flake was a saucer-shaped flake. He had come to the conclusion, after a very long period of observation, that when it was in that form it was the very strongest form in which they could have it. If the author would bear that in mind in his investigations, he might be able to prove it to the satisfaction of foundrymen generally, and probably to their benefit.

MR. NORTHCOTT said he had no experience with regard to malleable iron after chilling. He had been dealing recently with some special malleable cast irons which were taken out of the furnace at a red heat and allowed to cool down in the air, and then quenched from a black heat, and there were no good mechanical properties whatever.

As to Mr. Shaw's criticism of conclusion No. 8, which he had omitted to answer, he was convinced that his figures were the correct ones—at any rate for the iron he was using. It was not unreasonable to suppose that, by decreasing the pouring temperature—certainly on the outside of the casting—there was less graphite, for the simple reason that with a high pouring temperature they had an excess of heat to warm up either the sand mould or iron mould, whichever was used, and that would decrease the rate of cooling of the metal. Whether or not that would affect the inside of the casting would depend, to a large extent, on the size of the casting.

Total Carbon Content Queried.

MR. H. J. YOUNG, referring to Tables II and III, said that if the author had had a little more experience he would not have published those two tables, because the only answer to the criticisms made upon them was that the iron was not in equilibrium. If it were not in equilibrium, what was the good of publishing the tables? If the author had carried out the tests 99 times with the iron not in equilibrium he would have got 99 different results. He agreed with Mr. Shaw that they had no meaning whatever. He had noticed that the total carbon of these pig-irons was 3.2 per cent. He himself used a great deal of pig-iron, and would be very glad if it contained only 3.2 per cent. total carbon. He received it sometimes, but that was not the normal iron; it was a very low figure for pig-iron. He knew that makers advertised pig-iron containing 3.2 per cent. total carbon, but when the consignments were analysed, they usually found about 3.6 per cent., and when the makers advertised 3.6 per cent., they found about 4 per cent., and so on. Therefore, 3.2 per cent. was a very low figure, and the fact that Mr. Northcott had been working on a 3.2 per cent. total carbon pig-iron was a point of importance. If he had had a total carbon content of 4.2 per cent., as was the case with many hematites, some of the figures obtained might be very different. Mr. Young said he was astounded when the author said that the size of the specimens was 1 cm. square, and he did not think that those working in engineering works would be impressed with the results obtained on such small specimens. It meant that the author had been working on surface more than upon mass. The specimens dealt with in the second part of the Paper were 6 in. long and 1 in. in diameter. That being so, he would like to ask the author how he explained Table VIII. He did not think Brinell results of reliable value could be obtained on 1-in. diameter bars if the idea was to compare results on the edge with those taken in the centre. He was speaking from the practical point of view. Moreover, he did not think the graphite results in the table were correct. The graphite in the centre of a 1-in. bar would, in his opinion, be very little different from what it would be towards the edge, unless they took the outside skin—perhaps 1/32nd from the outside edge Also with regard to the percentage of graphite in the centre, given in the table, he did not think there was much difference between any of the specimens.

Molten Iron is Free from Graphite.

He agreed with the author that there was no free graphite in molten cast iron, unless it were super-saturated and some pig-irons contained much carbon. With 3.2 per cent. total carbon, at any rate, he did not think there was any free graphite. In conclusion, Mr. Young suggested that the author, if he continued his work, might take one little table out of the Paper and carry out intensive work upon it, and then read a Paper on his investigations. All would find a great deal of interest in it.

What is Refined Pig-Iron.

MR. NORTHCOTT, after thanking Mr. Young for his remarks, said, referring to the size of the specimens of white iron used for annealing experiments, as far as he could see—he did not wish to be dogmatic about it—the specimens used in the malleable industry in this country were generally not very big, in section at any rate, and, irrespective of the size of the specimen, he held that the temperature had the chief influence on the shape of the temper-carbon. Whether they used a big or a small specimen, if they used the same temperature and annealing conditions, they got the same form of graphite. As to the percentage of total carbon, the iron he obtained was a refined pig-iron, obtained locally. He had purchased it himself, the analyses were his own, and he held to them.

MR. YOUNG asked exactly what Mr. Northcott meant by "refined" pig-iron.

MR. NORTHCOTT replied that, as a matter of fact, he did not know. (Laughter.) It was sold as a refined iron by a company which called itself a refining company. He had seen some of it made, and he supposed that, to a certain extent, it was refined. In reply to further questions by Mr. Young and by Mr. H. Field, Mr. Northcott said he did not know whether it was cold blast, but agreed that it was a cupola-melted iron.

MR. YOUNG: Then it is a cast iron?

MR. NORTHCOTT agreed that it was. Continuing, Mr. Northcott referred to Mr. Young's remarks as to Tables II and III, and said he was afraid Mr. Young could not have appreciated the figures. He (Mr. Northcott) was doing research work, and it was his pleasure to find out things which, as yet, were not known. It was useless working on things that were known. The figures in Tables II and III were his figures, and the analyses were done by himself, and, even if Mr. Young did not think the two tables were of any use, he might or might not think that Table IV, which was a combination of those two, was of some use. Whether that was so or not, he did not know, but he hoped that several other members would take some interest in the results given in Table IV and in Graph II.

Brinell Hardness and Graphite.

MR. A. MARKS said those who had carried out research work on a large scale knew that their results did not always coincide with those obtained from work on small specimens. On the other hand, efforts to examine the question under somewhat different conditions were always to be considered with interest, and it was for those with more experience of work on a practical scale to give workers such as Mr. Northcott every assistance they could to apply the results to practice. There were one or two statements in connection with the Paper that those who had experience of work on a larger scale knew were not quite correct. For instance, the relation of Brinell hardness to the graphite content. If Mr. Northcott would try experiments with 3 or 4 tons of cast iron under various conditions he would find that he could get a Brinell hardness figure which was higher in a casting with a higher graphitic content than he could with a casting with a low graphitic content. One would anticipate, from

ordinary experiments, that with iron with a high combined carbon content one would have a high Brinell figure, but it was possible to get an iron with a low combined carbon content with a higher Brinell figure, so that the author's conclusions, whilst quite easily true when working with small specimens, are not applicable generally.

Free Graphite and Molten Cast Iron.

With regard to free graphite, this was generally spoken of by scientific men as not existing in molten cast iron, but it still had to be explained why the practical man could walk round the foundry and watch a casting poured, noting the break of the metal, and know whether the casting would be hard or soft. The scientific knowledge of some very capable foremen whom he had met was remarkable, and one could not help but call it scientific knowledge. Without any laboratory knowledge of estimating his graphite, the foreman could say, simply by skimming the ladle, what kind of iron he had. He took skimmings off the top and ascertained the graphite content of it, and found that the graphite content was an accurate guide to the softness or hardness of the iron. Therefore, whilst it is held that free graphite did not exist in molten metal, it must be recognised that here was a practical test in everyday use, where the graphite content was an indication of the condition of the resulting cold metal. With regard to the diagrams in the Paper, Mr. Marks warned Mr. Northcott that most of the diagrams which had been published in connection with metals were the result of tests made on very small specimens, and they were very misleading.

MR. NORTHCOTT thanked Mr. Marks for his kind remarks, and agreed to a large extent as to the scientific knowledge of the practical man. There was no doubt that foundrymen generally could tell the condition of irons, but there was no doubt also that there was a theoretical and scientific explanation for it. With regard to the soft metal, and the information obtained from skimming a ladle, he believed that might be due to the formation of kish. Kish, generally, was not formed except in high-carbon irons, and those irons generally had a considerable amount of graphite; consequently—though not necessarily—they were softer irons.

PROF. A. CAMPION said he had only one suggestion to make with regard to this very valuable Paper. For a long time he had thought that insufficient attention was given to the size and formation of graphite. There was only one particular iron dealt with in the Paper, and to say that the equilibrium conditions were attained at 2 or 2.2 per cent. graphite did not convey very much. It would be better if after examination of many irons they could work to some definite ratio to the total carbon; for instance, if they said that when a certain percentage of the total carbon was in the graphitic condition, equilibrium conditions were obtained, it would be better.

MR. NORTHCOTT said it was impossible to get out the formulæ for any iron.

PROF. CAMPION pointed out that nothing was impossible.

MR. NORTHCOTT replied that perhaps it was possible, but the values would be quite useless. The values obtained for the iron he had used were to a very large extent approximately the same for any irons, and, even if they were going to vary the total carbon in any iron, he believed it was true to say they would not alter the combined carbon content at equilibrium temperature.

MR. E. LONGDEN, referring to statements made to the effect that graphite was formed after solidification, said that if that were so, why did one get a lesser shrinkage in grey irons as compared with white irons?

MR. NORTHCOTT replied that white irons contained a considerable amount of their carbon in the combined state, and it was present as Fe_3C (iron carbide). That had a definite shrinkage value, just as all substances had. In grey iron, however, one molecule of carbide broke up into three of iron and one of carbon ($3Fe + C$). It was the expansion due to that reaction which prevented grey irons from contracting very much.

MR. E. LONGDEN asked whether the pressure exerted by the cooling envelope of the metal on the molten centre induced shrinkage.

MR. NORTHCOTT said that the reaction generally took place just following the solidification point of the metal, and some metals actually expanded just after the solidification point was reached. Usually, however, there was shrinkage after the reaction had taken place.

THE PRODUCTION OF CASTINGS IN PERMANENT MOULDS.

By R. J. ANDERSON and M. E. BOYD.

MR. H. COLE ESTEP presented this Paper, and said it was an exchange Paper on behalf of the American Foundrymen's Association. Mr. Estep regretted that the authors could not come to England for the purpose of reading the Paper personally. This was the fourth year in which the exchange of Papers between the American Foundrymen's Association and the Institute of British Foundrymen had taken place, and the arrangement come to was perhaps one of the most significant and important that had taken place for a good many years. The American Foundrymen's Association would always feel indebted to Mr. Cook for having gone to America two years ago to read his Paper there, and the American Association hoped to follow that example in the future. Speaking of the Paper, he said he hoped there would be some discussion upon it. Mr. Anderson was one of America's most prominent scientific foundry engineers who had had practical experience, and had carried out much work on the problem of permanent moulds for cast-iron shell and aluminium aeroplane engine parts during the war.

ECONOMICAL MELTING WITH CUPOLAS.

By H VAN AARST.

MR. H. VAN AARST, JUN. (Holland), presented the Paper which had been contributed by his father. In doing so, he very much regretted that his father had been prevented from attending the Convention owing to illness. He had been charged to present to the Convention the heartiest greetings and best wishes from Dutch foundrymen, who hoped that the Convention would be as successful and valuable as the Institute itself hoped it would be. Also, he expressed the hope that members of the Institute would find an opportunity to visit Holland when a foundry conference was being held there. He was astonished to realise that English foundrymen had made such very great progress as they had during the last twelve years or so. Some years ago he had been to Tyneside in order to learn how to make castings, and he was pleased to be able to say that, with the aid of the English people, the Dutch had been able to make good castings themselves.

NON-FERROUS ALLOYS IN MARINE ENGINEERING.

By A. LOGAN.

MR. E. LONGDEN asked whether better results would be obtained by running the bearings from the bottom instead of from the top.

MR. LOGAN said that was actually what was done.

Water-cooled White Metal Bearings.

MR. F. J. COOK asked whether the author had had any experience of water-cooled white-metal bearings, and whether water cooling assisted in the formation of the cubes, which were so essential.

MR. LOGAN said it had never been the practice at his works to water-cool a bearing immediately it was cast.

MR. COOK said he meant water-cooling whilst casting.

MR. LOGAN replied that they had never done that, because a certain amount of contraction or shrinkage took place and the bearing was practically allowed to remain liquid a short while to enable feeding to proceed. In his opinion if they water-cooled while casting they might stand a chance of getting spongy places. They cooled with an air-blast and had tried what was really

a fine water-and-air spray. It was certainly advisable to cool off as bearing to remain hot longer than was necessary it gave time for the crystals and grain size to grow. In his firm's bearings the actual size of the tin-antimony cubes was 0.06 in.; they did not want them too large. For the size of bearing they were dealing with he did not think water-cooling was essential, and these were the largest marine bearings.

MR. COOK said that, after 20 years' experience, he had found that water-cooling when casting was of very great importance in dealing with bearings larger than 13 in., and for small bearings, for high-speed work, it had been essential. It gave sounder castings with less porous places and better formation of the cubes.

Temperature Control.

PROFESSOR CAMPION said the author had finished up with a very important warning to foundrymen with reference to temperature control, and had pointed out that temperature, beyond everything else, should be most carefully adjusted, or else the final result would be failure. But he (Prof. Campion) considered that the author should have mentioned the time factor as well as temperature, more particularly the rate of cooling, because, after all, one of the main objects in controlling the casting temperature was apart from preventing overheating to secure proper cooling conditions. The properties of metals, and especially the non-ferrous alloys, depended very much upon the rate of cooling. Therefore, Mr. Logan had done foundrymen a very good service in impressing upon them not only the necessity for buying instruments, but for actually using them.

Bottom Pouring Linings.

MR. A. MARKS, speaking of bottom-pouring white metal, said this was advocated by quite a number of people, but white metal could be poured quite satisfactorily from the top, and, at the same time, it could be fed from the top. The essential factors in order to have a clean casting were that they should pour vertically, and allow the dross to rise. At the National Physical Laboratory they had made quite a number of experiments on the pouring of aluminium alloys from the bottom, but pressure-fed from the bottom of the ladle—not poured from the top of the ladle; but, if they tried to pour a 24-ft., or even a 20-ft., job from the bottom, they would find they were against difficulties in more ways than one. The author had mentioned that he had had trouble with a bearing made with one of his alloys, and a micro he had exhibited had shown a copper constituent —which was a hard constituent—standing out in its soft matrix. If the antimony crystal was essential for the job, then either the author's theory—that a hard constituent in a soft matrix was necessary—was wrong, or the bearing should have worked perfectly, because the essential conditions which he had claimed for a bearing, namely, that there should be a hard constituent in a soft matrix, were present. He (Mr. Marks) suggested that the trouble was probably due to the presence of lead; anyone who had been responsible for bearings for large jobs knew the trouble that might arise when there was lead present. If they took friction tests on alloys containing lead, it was found that the coefficient of friction rose very rapidly with the percentage of lead. In his view a bearing alloy could be made quite successfully without antimony present. It could be made by utilising just the copper constituent, and one of the best methods of dealing with bearings for Diesel engines was to increase the copper constituent, to give a little more stiffness, in order to enable it to resist the sudden impulses which occurred in the best regulated Diesel engines. Then the author had asked for experiences on annealing Admiralty bronze.

Tensile Strength of Bearing Metals.

According to the theory enunciated that morning, which was generally accepted—although he personally did not altogether agree with it—a bearing metal should have a minimum tensile strength, owing to the fact that they were trying to put in a large number of these hard spots. These hard spots were usually very brittle alloys. The more that were put in the better the bearing metal, but also the more they put in the weaker the bearing metal, and therefore for a Government Department to raise the tensile strength figure to 16 tons was a ridiculous proposition. He referred to a particular liner which he had cast for a cruiser. The liner was 22 ft. long and something of the order of 16 in. in diameter. When tested it was found to be half a ton under the minimum tensile strength. Accordingly, he went to an officer at the Admiralty and had pointed out that the liner was a perfect one, free from oxide, and it was a bearing metal, but the reply was that they must have the other half ton. Without that extra half ton, said Mr. Marks, it was a better bearing metal than with it. However, he obtained permission of the Admiralty to anneal the liner, and had brought it up to over 20 tons tensile. That was accepted without a word. It is now running on one of the large cruisers, and he has not yet heard that it had worn out. He had not the slightest doubt that the liner, with its low delta constituent, was giving as good service in the Navy as was any other job, and therefore he was sure that this theory of hard spots in lubricating metals was really rather ridiculous.

Casting Temperatures.

There had been much nonsense talked in scientific societies about casting temperatures. In the foundry they had to drop-cast a metal by anything from 10 to 20 ft., and one found that by doing so they broke up the oxide and prevented it adhering to the mould. Great emphasis had been laid upon the temperature of the metal, but he had heard nothing yet as to the temperature of the mould, the amount of moisture in the loam, the amount of venting, or the construction of the mould, all of which had a far more important bearing on the resulting casting than the actual 10 or 20 deg. variation in the metal, on which such great emphasis had been laid by various writers. Much careful work had been done at the National Physical Laboratory on the question of casting temperatures. In casting a liner the mass of the mould was a very different factor from the mass of the metal. If the liner weighed 15 tons the crane, when lifting the job out of the pit for opening the mould, was lifting something of the order of 20 to 30 tons. Supposing the temperature of the core-drying or mould-drying stoves were 10 or 20 deg., or even 100 deg., lower than usual, it was probable that, even after giving the mould three days drying, it might not be satisfactory. But the Admiralty, or whoever required the liner, wanted to get their ship on the water, and the man in charge of the operations might risk it. He might have 10 per cent. excess of water in the mould which had to be shifted, and he had to have excess temperature in his metal in order to remove it. Therefore they must take these statements with regard to the necessity for the exact measurement of temperature with a grain of salt.

Zinc Equivalents and Manganese Bronze.

Mr. Logan had referred to the zinc equivalent of certain alloys, and he (Mr. Marks) would like to know whose figures he had taken for calculating the zinc equivalent. There were various figures available, and the author would get 1 or 2 per cent. difference in his figures by using different people's equivalents. Again, reference had been made to the "blue-etching constituents" in manganese brass, and also to the question of iron in manganese brass. His own opinion was that iron in manganese brass was one of the chief disadvantages of that material. The author had given a figure of 1 per cent. That was quite a usual figure, but, on the other hand, it had been proved conclusively that 0.7 per cent. was about the maximum which would go into solid solution, and even then, on a large job, they were liable to have trouble. It was one of the chief causes of trouble in propellers. He had been running some experimental propellers over a period of six years, and this question of iron was a very important one. However, propeller troubles were like foundry troubles in that there was a great deal of difference of opinion about them.

Bottom Pouring White Metal Bearings.

MR. LOGAN, after expressing his thanks both to Prof. Campion and Mr. Marks for their kind remarks, referred to Mr. Marks' criticism of

bottom pouring. When he had mentioned bottom pouring in the Paper he was speaking particularly of white metal. Mr. Marks had also mentioned gunmetal, but he did not think that came into the discussion at all. His firm had found that the best means of getting sound white metal bearings with the least trouble was the method of casting on end and running from the bottom, and he still held that they could get quite sound bearings by doing so, provided they kept the head liquid and allowed feeding to take place. The melting furnace they used might have something to do with the soundness they obtained. The metal was very clean, and kept under non-oxidising conditions. The only dross likely to get into the bearing was simply that formed during pouring, and was very, very small. The whole of the bearing was molten for a minute or so, and that was a sufficient time to enable any dross in the material to come to the head. As to the theory of the hard constituents in the soft matrix, Mr. Marks did not think that the very small antimony content was the cause of the bearing failure mentioned. There were many compositions on the market—one of Messrs. Stone's compositions, he believed, contained about 15 per cent. lead, but it also contained a considerable proportion of antimony. The main point was that, although the copper-tin

MR. H. A. J. RANG,

whose resignation of the Secretaryship of the Newcastle Branch of the I.B.F. we announced last week.

dendrites were relatively hard, the total area of such hard constituents was not enough. In other words, the Cu-Sn solid solution had to be backed up by the additional area of the antimony cubes also. Mr. Marks had said that increasing the copper content was as effective as increasing the antimony, but he (Mr. Logan) did not quite think that. He considered that the tin-antimony cubes were very much harder and with them a bigger area has a special part to play.

With regard to the annealing of Admiralty gunmetal, Mr. Marks was quite correct in saying that they could get a considerable increase in the tensile strength simply by annealing, possibly, even an extra 4 tons. From a 12-ton gunmetal they might easily get 16 tons by annealing, but the effect of annealing was to remove entirely the as-cast structure and to give a completely homogeneous tin-in-copper solid solution. The result was completely to absorb the delta constituent, and, of course, to reduce the hardness, which was also to reduce that constituent which was vital to a good wearing bearing. The liner referred to by Mr. Marks was running satisfactorily, because the pressures in use were only a few lbs. per square inch, but if they wanted satisfaction from a bearing subjected to strenuous conditions they must have the delta constituent present in quantity. As to Mr. Marks' view that a few degrees difference in the temperature of the mould, or a few per cent. difference in the moisture content, would make more difference than 10 or 20 deg. difference in casting temperature, Mr. Logan agreed. In green-sand work especially, the differences in the condition of the mould would have a very large effect; but when he was talking of casting temperatures he was assuming dry-sand work, which was the work he was concerned with mainly. Given similar conditions, casting temperature was very important, and it should be attended to, even though there might be differences with green-sand moulds. As to the zinc equivalent, Mr. Logan said he would deal with that in writing.

Iron Content of Manganese Bronze.

With regard to Mr. Marks' reference to iron in manganese brass, and his statement that 0.7 per cent. of iron was the maximum that would go into solid solution, he (Mr. Logan) was not prepared to dispute it, but he had given 1 per cent. as the maximum for general work, and he believed that that was lower than some people worked to at present. Some manganese brasses on the market contained more than 1 per cent. of iron—sometimes 2 per cent.—but he considered that 1 per cent. was quite safe. They did not get segregation of the "blue etching constituent," or a great excess if the iron was kept to about 1 per cent.

THE TECHNICAL SIDE OF OIL-SAND CORES.

By C. W. H. HOLMES.

MR. W. T. EVANS said that, as one with experience of oil-sand cores, he was of opinion that this Paper was one of the best on the subject that he had so far encountered, and he was in accordance with the whole of it. At the same time, he asked for information on steel-shot cores, which Mr. Holmes, in his modesty, had left out.

Steel-Shot Cores.

MR. HOLMES said he had not dwelt upon steel-shot cores because he did not wish to waste time. There was nothing more to say about them, except that they were fairly difficult to make, and would not "stand up" readily. The weight of the steel-shot made them tend to "sit down," and it was a question of either making them on a flat-plate, which had to be machined, or making them in a drier. He had found them very useful in castings where there was a big boss, and the designer had seen fit to put a 1-in. hole through, and there was about 4 in. of metal all round it. He did not say that that was a perfect way of getting over the trouble; there were other ways, but in a foundry which was casting different types of work they could not run a different kind of metal down every five minutes, and sometimes they had to run thick sections with metal which was hardly suitable for it. In such cases it paid, in his opinion, to use a device of this sort rather than to use a special grade of metal, unless, of course, the output warranted it. But he would certainly not recommend them for indiscriminate use, on account of the cost. Of course, the steel-shot was more expensive than sand, and unless they had a magnetic separator they did not completely recover the shot. He had not found it doing any harm in the sand, but he had found that the new shot which had to be put in to make up for the old shot which was lost was just about the amount they had got to use to make a strong core. One had to use a fair amount of gum to hold them together, apart from core oil, and apparently there was a tendency to get a different type of coating on the shot than on the sand grains when they had been used more than once; after the shot had been used three or four times it had not a very good surface.

MR. J. LONGDEN referred to the question of whether it was better to add the emulsified oil to the sand after drying, in preference to adding it to a green sand. It seemed to him that a great deal too much was made of that. He was of opinion that, when a green sand was used and oil added, the mixing of the oil which

was added to the water already present, induced a sort of emulsification during the mixing process. He had never found the necessity for drying the sand before adding oil. Finally, he asked Mr. Holmes what, in his opinion, was the maximum thickness of section which it was safe to use round an oil-sand core, because he had heard of cases where oil-sand cores had collapsed when used for very heavy castings.

MR. HOLMES, dealing with the amount of grains in a given quantity of wet or dry sand, said that a cubic foot, or any other measure, of wet sand did not contain so many grains as a cubic foot of dry sand. He illustrated what happened in two containers of, say, 1 cub. ft. capacity, filled with wet and dry sand respectively, by means of a sketch. If the sand were dry, he said, there was nothing at all to stop the grains touching each other, but, if the sand were damp, the water would collect at the points of grain contact. There was a certain amount of surface tension which became quite appreciable when one considered the large number of grains contained in a cubic foot of sand. If the grains were pushed together the water would push them apart again. Another thing which stopped the sand grains settling down perfectly was the fact that there was, to a certain extent, more friction.

Emulsification of Oil Through Mixing.

With regard to the emulsification of core oil, he did not say that they could not make a perfectly good oil-sand core without emulsifying; they could do so, and he had seen many. But, if they did emulsify it, they could do it better in a proper apparatus, and he had such an apparatus. The ordinary method of mixing oil and sand was designed simply for mixing oil and sand, and not for emulsifying oil and water. It was quite possible to make oil-sand cores in the oven in the kitchen, but the oven was not designed for the job and would not do it so well as a specially designed stove. In his opinion it was much better to break the job up into two operations. If they were making a lot of cores, and wished to get the best possible results with regularity day in and day out, his advice was to dry the sand.

Maximum Size for Oil-Sand Cores.

He could not give any definite information on the subject of the thickness of section which it was safe to use round an oil-sand core. The largest thickness of metal he had run round such a core was 2½ in. The job was a fairly heavy wheel, with a rim about 2½ in. thick, but it would be rather thicker in the boss. That was as far as he would care to go. They should not have a greater height of metal than they could possibly help for an oil-sand core, because, if it started to collapse before the metal had set, they would get the core distorted.

MR. OLIVER STUBBS said that a member of the Institute, a few days previously, had made a casting 22 tons in weight, with a mixture of 1 in 40, oil-sand cores, with a 9-in. thickness of metal. Asked what was the size of the core, Mr. Stubbs said he should think it was possibly about 7 ft. 9 in. long. It was oblong in shape.

MR. E. LONGDEN asked the conditions under which it existed in the mould—vertical or horizontal.

MR. STUBBS said he would be glad to get information about that. He had mentioned the fact merely because Mr. Holmes did not go beyond a thickness of 2½ in. His own firm were regularly casting up to 4 and 5 in. thickness of metal with no trouble whatever.

MR. HOLMES said he meant that he had only gone up to 2½ in., but he could see that they could go further. He had said in the Paper that oil-sand cores could be used for heavy castings, but, in the fourth paragraph of the last section, he had pointed out that there was a limit, which was reached when the resinous bond in the core was burnt out before the metal had solidified. He went on to quote: "When this occurs, the core is either distorted to a more or less shapeless mass by the pressure of the metal, or crumbles and floats up under the cope. When it is borne in mind that each foot in the height of the molten metal exorts a pressure of 3 lbs. per sq. in., it is obviously unwise to set a core with any chance of crumbling at the bottom of a deep mould unless the metal thicknesses are so small as to permit of rapid setting of the metal. When working close to this limit, it is important that the cores must not be over-baked." However thick or however thin anybody happened to make castings from oil-sand cores, he said, that was the practical limit, and those were the considerations underlying it.

MR. A. MARKS, dealing with the size of the castings which could be turned out with oil-sand cores, said that those with practical experience of oil-sand core-making knew that they could have an oil-sand core of any size if they could persuade the foreman to make it. One met with a good many old foremen who had vast practical experience and who liked to go gradually. The standing up of a core to the metal was a question of the consistency. Even for small automobile work he had three or four oil-sand mixtures which he used for different purposes. For example, he could not make, say, a jacket core of the same consistency as a core to be used for a 36-in. diameter pipe, and anyone who was familiar with walking round a foundry and testing cores could see at a glance whether the mixture was made right. No limit had yet been reached with regard to the use of oil-sand cores, but they ought to get down to the essential underlying principles. Mr. Holmes had given a very good practical Paper, but, if progress was to be made in this matter, they should understand the principles underlying oil-sand cores more thoroughly. In regard to binding, Mr. Marks was not at all convinced that it was necessary to have a perfectly clean sand, as Mr. Holmes had termed it. He was not convinced that oil and an absolutely free pure silica would give a perfect core. In sea sand there was something besides free silica; there was ferric oxide, and two or three other minor constituents. Also, there was a considerable proportion of sodium chloride present in any dry sea sand, and the influence of that had not been taken into consideration in connection with these oil-sand cores. From the practical point of view, they had taken this into consideration by rule-of-thumb methods, and had gradually gained experience, but they would have to look at it scientifically as well as practically. At present they were in the hands of the core-oil maker. He submits a certain brand of oil, and, by experience, the users get to know its idiosyncracies. It might be right or wrong; frequently it was wrong. Perhaps Mr. Holmes had been up against that difficulty and had, therefore, failed to make castings of larger sizes than those he had mentioned. The question of the minor constituents in the sand would be well worth investigation, followed by an investigation of the binding powers of the different varieties of oil.

MR. HOLMES asked whether it paid to use an inferior sand and a greater quantity of oil. As to the minor constituents of sand, he had made perfectly good oil-sand cores with sea sand, river sand, and dune sand. He had not found anything in sea sand that one would not expect to find, and had not found, from practical experience, that salt made any difference. It might do, but he considered it most unlikely. As to Mr. Marks' point that these things had to be looked at from a scientific point of view, Mr. Holmes said he had only had a week in which to write the Paper, and could not do much scientific research in that time. He also pointed out that he hoped, at a later date, to go into the thing more thoroughly, and, instead of giving a descriptive paper, to give one which would be simply a mass of facts—the sort of paper that could not be read, but which would have to be given to people for them to digest at leisure.

Shell in Sea Sand.

MR. B. HIRD asked if small shells in sea sand affected oil-sand cores, and whether they were responsible for some oil-sand cores made from sea-sand blowing occasionally. He had had difficulties with that kind of sand, and had attributed them to shells. Mr. Hird added that, when he was short of sand for oil-sand cores, he had found that a fairly good substitute was the ash gathered from the top of the cupola.

MR. HOLMES, dealing with the possibility of cores blowing through the presence of pieces of shell, said that the only case he could see in which that was likely to occur was where the pieces of shell were fairly large, but he did not think that,

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apart from the mechanical obstruction caused by the pieces of shell, there was much risk of blowing. In the case of sand which had been knocked in the fettling and used again, with shells in it, they might, through heating, get the shells rather porous, so that they absorbed oil; if they made the mixture fairly rich, with the sand on the wet side, they might get a good deal of oil collecting in the shell, and, if it were near the surface, blowing might occur. But, speaking generally, by taking out the larger pieces of shell in sea sand, he had not found any trouble, though there was just a possibility that there might be trouble in a very narrow core. He was quite interested to hear Mr. Hird's reference to cupola ash, which was quite a new material for making oil-sand cores.

Binders Other than Oil.

MR. E. H. BROWN asked the lecturer whether he disagreed entirely with the use of binders of the nature of glucose. With regard to the baking of cores, he would like to know whether Mr. Holmes considered that oil-sand cores should be dried in a separate stove, or whether, if oil-sand and the naturally-bonded core sand had to be dried in the same stove, there must be separate heats. Even to-day there were a large number of foundries which were anything but up-to-date, and the foreman had to make the best of a bad job. Mr. Brown then referred to a recent experience which might interest members. In the last three weeks he had seen some very thin oil-sand cores, the section being between ⅛ and ¼-in. thick, built into a very thick section of metal. The total thickness of metal, including the core, was practically 6 in., right at the bottom of a fairly heavy mould. The cores were made in oil-sand, using a very fine sea sand as a base. After being dried, they were further spread with oil and baked again, and when the cores were knocked out they were found to be perfect.

MR. HENDRIK VAN AARST.

Mr. Van Aarst, who presented a Paper to the Newcastle Conference, is a well-known Dutch foundry manager. He is connected with Werkspoor concern at Amsterdam and a new foundry at Zuelen, near Utrecht. He has also edited the technical journal "De Yzer en Staal Kronick." He is President of the Dutch Foundrymen's Co-operate Association, which is both a technical and buying association.

MR. HOLMES, replying, said that he was speaking generally of drying oils in the Paper, and "drying oils" meant something with a linseed or similar base, but he had no objection to the use of glucose. They could use all sorts of things, but he was not dealing with that question at the moment. There were a large number of imitation core oils on the market, consisting of wood extract, pulp extracts, and similar materials, as well as gums; as a matter of fact, they could call anything a core oil nowadays, when it was not an oil at all. It was not so much a question of baking with other materials, but, in the case of the linseed base oil or a similar product, they had to oxidise the material; that was a distinct baking action, and not a drying action. It was not merely a question of drying out the moisture and leaving something that was sufficiently strong; they had to dry out the moisture and make something fairly weak, and then act on it further by hot air and strengthen it, not by drying but by oxidising. If a glucose binder happened to suit the particular type of work for which it was used, and it was an economical proposition, his advice was to stick to it. As to the baking of cores, he had found that if they wanted the very best thing in oil-sand cores they had to have their own heat treatment, and that did not fit in with the proper conditions for drying a naturally-bonded core. Reverting to the question of core oils, he said that some of the oils on the market appeared to contain two constituents which required quite different thermal treatment in order to get the best out of them. That was a point which some makers of core oils did not appreciate. Dealing again with the question of separate stoves, Mr. Holmes said that if the volume of work justified the use of separate stoves, well and good, but there were so many factors entering into the question that it was quite impossible to say whether it was a more economical proposition to get a slightly worse core through giving it the incorrect heat treatment, or to spend more money in order to get good cores.

MR. STUBBS asked if Mr. Holmes would give information in writing with regard to testing oils for specific gravity, flash points, and other tests that he had made, because there was nothing that had been so much exploited in the foundry trade during the last two or three years as core binders and oils had been, and to his mind there was either a real good thing in it or else foundrymen did not know what they were doing. If Mr. Holmes would give that information, it would help them to come to a conclusion as to which was the best binder they could use.

In reply to Mr. Stubbs, MR. HOLMES said he did not feel in a position to discuss this as he had very little knowledge of organic chemistry in general or the testing of oils in particular.

In any case, it seemed doubtful if the laboratory testing of core oils, other than by an expert using exhaustive methods of investigation, would throw any light on such complex properties as those which render the handling of the core in the foundry possible or not.

Much time and money is spent each year on conducting rather futile tests on lubricating oils, and probably the same thing would happen in the testing of core oils.

The problem was one that might well be attacked by the British Cast Iron Research Association (after the present urgently-needed researches are completed), together with one or more experts on the subject; but so far as the foundry laboratory was concerned, the subject was almost beyond its scope.

THE PRESIDENT, in bringing the discussion to a close, said that that was information which they were all looking for. He also expressed indebtedness to Mr. Holmes for his Paper.

DILATOMETRIC STUDY OF ALLOYS.

By P. CHEVENARD.

THE PRESIDENT, after expressing his regret that time did not permit of the discussion of this valuable Paper, said that the members of the Institute were very deeply thankful to Mons. Chevenard for the immense amount of work that he must have put into his subject. It was one of the most valuable Papers which the Institute had had the pleasure of listening to. Also he expressed thanks to Mr. Faulkner for having translated it, a task which must have been stupendous.

The vote of thanks was carried with acclamation.

MONS. CHEVENARD, addressing the meeting in French, returned thanks for the kind manner in which his Paper had been received, and expressed appreciation of the help which Mr. Faulkner had given him.

MR. F. J. COOK, on behalf of the British Cast Iron Research Association (of which he is a Vice-Chairman), said that the Association looked upon the Paper as one of the most valuable that had been presented for a long time, and assured the Institute that there would be a good discussion of the Paper in writing.

Trade Talk.

THE L. & N.E.R. have decided to erect at a cost of £90,000, a new steel viaduct at North Seaton, Northumberland, over the River Wansbeck.

THE ITALIAN TREASURY is inviting tenders for the right of working iron ore in the Elba Island. The rights are to have a currency of ten years.

HARGREAVES & REDFERN, iron, tinplate and metal merchants, have removed their head office from 19, Old Millgate, Manchester, to 311 and 313, Leeds Road, Bradford.

A FIRE BROKE OUT recently at the Rosebank Ironworks, Edinburgh, belonging to Brown Brothers, as a result of which the patternmaking shop was destroyed.

THE STIRLING BOILER COMPANY, LIMITED, London, E.C.4, have, owing to increase of business, removed to more commodious premises at 32/33, Farringdon Street, E.C.4.

YARROW & COMPANY, LIMITED, Scotstoun, Glasgow, have received an order to build one of the two torpedo-boat destroyers for the British Admiralty, as provided for in this year's Naval Estimates.

MR. L. D. WHITEHEAD, of the Whitehead Iron and Steel Works, Newport, has opened a new recreation ground and pavilion for his employés at Maesgeas, Newport. Next year, he said, he hoped to add tennis courts and other attractions to the grounds.

LICENCES HAVE BEEN GRANTED under the Non-Ferrous Metal Industry Act, 1918, to Gilbert Marchant & Company, 49-54, Broad Street Avenue, London, E.C.2, and A. D. Keeling & Company, Limited, Warstone Metal Works, Hall Street, Birmingham.

IN ORDER to cope with increasing business, Wailes, Dove Bitumastic, Limited, have acquired the extensive buildings and works of the Alby Carbide Factory, Hebburn, which were built during the war. The firm are installing an entirely new plant for the manufacture of bitumastic and the refining of the necessary raw materials.

ARRANGEMENTS HAVE BEEN MADE by the Wellmar. Smith Owen Engineering Corporation, Limited, to extend the company's works at Willenhall for the purpose of manufacturing machinery for special rolling mills for production of solid drawn steel tubes, which business is handled by one of the subsidiary companies, and a loan of £70,000 guaranteed by H.M. Treasury has been granted to the company for this purpose. These extensions are well in hand, and the subsidiary company in question has already booked an important contract for a complete tube-making plant.

Contracts Open.

Dungannon, July 3.—Supply and laying of some 480 yds. of 6-in. cast-iron pipes, for the U.D.C. and Joint Committee. Mr. J. H. H. Swiney, Avenue Chambers, Belfast, or Mr. W. J. Beatty, secretary, Joint Committee, Town Clerk's Office, Dungannon. (Fee, £1 1s., returnable.)

Keighley, July 14.—Steel joists, etc., for the Keighley Corporation. Mr. M. Ratcliffe Barnett, Town Hall, Keighley.

London, S.E., July 1-4.—(1) Copper firebox plates, (2) girder bridges, (3) galvanised steel sheets, corrugated and plain, for the Director-General, India Store Department, Branch No. 14, Belvedere Road, Lambeth, S.E.1.

Wellington, N.Z., July 1.—100 miles of galvanised steel cable and 20 tons of galvanised hoop iron suitable for earthing strip, No. 16 S.W.G., 1½ in. wide, to be supplied in ½ cwt. coils, for the Public Works Department. The Department of Overseas Trade.

Aldershot, July 1.—One 8-in. belt-driven centrifugal pump at their sewage works, Ash Road, Aldershot, for the Corporation. Mr. J. Neave, Municipal Buildings, Aldershot.

Cape Town, July 14.—Structural steel umbrella roof for main and island platforms, for the South African Railways and Harbours. The Department of Overseas Trade, 35, Old Queen Street, London, S.W.1.

Dublin, June 30.—One portable air compressor, and pneumatic boiler scaling tools for the Pigeon House electricity works, for the Corporation. City Electrical Engineer, Fleet Street, Dublin.

Edinburgh, July 8.—Twelve tramway trucks and relative electrical equipment of cars, car wheels and axles, and 12 air-brake equipments, for the Corporation. The Tramways Manager, 2, St. James Square, Edinburgh.

Company News.

A. E. Plumstead & Company, Limited, 120A, King Street, Norwich.—Capital £1,500. Acetylene welding engineers. Director: A. E. Plumstead.

H. Beare & Sons, Limited, 26, Salisbury Road, Newton Abbot.—Capital £15,000 in £1 shares (9,000 preferred). Engineers, etc. Permanent directors: T. L. and H. L. Beare.

James W. Joss, Limited, 115, Wellington Street, Glasgow.—Capital £3,000 in £1 shares. Engineers. Directors: Ethel E. Joss and W. H. A. Dinsmore.

London Works Iron and Steel Company, Limited, The London Works, Halesowen Street, Oldbury.—Capital £15,000 in £1 shares. Directors: H. W. Adshead (permanent chairman and manager), C. F. Gilbertson and P. N. Beeten.

Metro-Vick Supplies Limited, 4, Central Buildings, Westminster, London, S.W.1.—Capital £25,000 in £1 shares.

Obituary.

MR. F. SKELTON, chairman of the Canadian Tool Company, of Hamilton, Canada, who died at Ontario on June 7, was formerly connected with C. T. Skelton & Company, Limited, tool manufacturers, of Sheaf Bank Works, Heeley, Sheffield.

PRINCIPAL R. M. WALMSLEY, of the Northampton Polytechnic Institute, E.C., has died as the result of a street accident. From 1890-95 he was Professor of Electrical Engineering and Applied Physics at the Heriot-Watt College, Edinburgh.

MR A. J. STEVENS, J.P., died on June 14 at his residence, Lawnside, Stow Park Circus, Newport. He was aged 82. Educated privately and at Cheltenham College, he in 1866 went to Newport, where he took up a partnership in the Uskside Engineering Company and became its managing director. He was president of the South Wales Institute of Engineers in 1894-5.

Projected Iron and Steel Industry for Tasmania.—In a joint report on the development of the rock and mineral resources of Tasmania, Messrs. A. McIntosh Reid and P. B. Nye, Government geologists, made some interesting comments to the Tasmanian State Development Advisory Board. Dealing with iron ores, they stated that Tasmania possessed large deposits of iron ore of a varied nature in different parts of the island. With the exception of the chromiferous ores of Anderson's Creek, the brown hematites of Brandy Creek, and the high-grade hematites of the Penguin Creek Valley, only a small amount of developmental work had been carried out owing principally to the absence of transport facilities. The first step in the development of these deposits should be a thorough prospecting and opening up in order to determine their actual value and nature. This had been advanced sufficiently in some cases to warrant further steps being taken. Following the successful opening up of the deposits, the provision of transport facilities should be undertaken. It was not likely that the smelting plants would be erected at the mines, but at the nearest port, or the ores might be exported to the mainland. It was thus evident that the development of the iron ores could be greatly assisted by:—(1) The provision of transport facilities, such as harbours, and railways or tramways. Such facilities would assist also in opening up any agricultural or pastoral land. (2) The introduction of large quantities of machinery, etc., for building the railways, bridges, etc., for equipping the mines and for erecting the smelting plants. A conservative estimate of the reserves existing at the Blythe River, Dial Range (Penguin), Long Plains (Rio Tinto), which is only a few miles from the new development, and Zeehan district was 42,710,000 tons. In addition, there were reserves at the Nelson River (just above the Pieman on the West Coast), Rocky River, and at Hampshire. The ore contains up to 69 per cent. iron, but the average grade will not exceed 65 per cent. It is suggested that the natural outlet for this deposit is through Corinna. This would entail the construction of a 25-mile railway along the eastern bank of the Savage River. These deposits are now controlled by the Hoskins Company, of Lithgow, who have also big leases of iron deposits at Heemskirk. The Hampshire deposits are 28 miles from Burnie, and eight miles from the Hampshire railway station. The ore is of high quality. Individual analysis of the Zeehan field gives up to 70 per cent. of iron.

IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—The position in the Cleveland iron trade, although to some extent by no means so satisfactory as might be desired from producers' point of view, is at last on a more satisfactory footing than has been the case of late, with undoubtedly a somewhat better inquiry both in the home trade and on export account. In the home trade there seems to be a feeling that the bottom has been touched, and there is, therefore, more confidence in operating.

Business in hematite continues to be on a disappointing scale, but it is certainly no worse than it was a week ago. Makers, however, are keen to get orders on their books for the ensuing quarter or half-year, and are inclined to make concessions to get the business. Hence, while East Coast mixed numbers are still quoted at 97s. 6d. per ton, business could be done at anything up to 6d. per ton below that figure. The No. 1 quality is at a premium of 6d. to 1s. per ton. In the North-West area prices remain steady, with Bessemer mixed numbers 107s. 6d. per ton, delivered at Glasgow, 112s. 6d. at Sheffield, and 112s. 6d. at Birmingham.

LANCASHIRE.—There has been a slightly more active movement in this area of late, but consumers of foundry iron are continuing their policy of hand-to-mouth buying, and it is now improbable that any large purchases of iron will be made by the big foundries until it is known whether or not a further fall in the prices is to take place. Latest quotations for No. 3 foundry pig delivered equal Manchester rule, Derbyshire 101s., and Scotch qualities 115s.

THE MIDLANDS.—Markets in this area continue sluggish, with foundry pig in moderate demand. Ironfounders in the Black Country are short of inquiries for work, and their requirements are consequently restricted to immediate needs.

Metals.

Copper.—The tendency of values of standard copper of late has developed somewhat towards lower levels, although the position may be regarded as little changed since last reported. Home consumption is, however, fairly well maintained, and the placing of recent large contracts for electrical requirements ensures the continuance of a steady demand and a strengthening influence on values for forward metal. The situation in the States is rather less favourable, the domestic consumption being restricted, and export returns on a disappointing scale. Current quotations:—*Cash*: Thursday, £60 17s. 6d.; Friday, £61; Monday, £61; Tuesday, £60 15s.; Wednesday, £60 12s. 6d. *Three Months*: Thursday, £61 15s.; Friday, £61 17s. 6d.; Monday, £61 17s. 6d.; Tuesday, £61 12s. 6d.; Wednesday, £61 10s.

Tin.—Movements in standard tin during the past week have indicated a somewhat firmer tendency, this improvement being due to increasing confidence that the long period of declining values has at length been arrested. Current quotations: *Cash*: Thursday, £217 15s.; Friday, £220 5s.; Monday, £223; Tuesday, £222; Wednesday, £221 17s. 6d. *Three Months*: Thursday, £217 15s.; Friday, £220 5s.; Monday, £223; Tuesday, £221 15s.; Wednesday, £222 2s. 6d.

Spelter.—Rudolf Wolff & Company state that demand on the part of consumers consequent on more active business reported in galvanised sheets has slightly improved. The market, indeed, is in quite a sound position, but whilst buyers and sellers alike view the situation with apathy, there seems little prospect until fresh features arise of any very definite movement taking place. Current quotations:—*Ordinary*: Thursday, £31 7s. 6d.; Friday, £31 10s.; Monday, £31 17s. 6d.; Tuesday, £31 17s. 6d.; Wednesday, £32 5s.

Lead.—The market for soft foreign pig has shown an irregular tendency, with values inclining to lower quotations. Consumption, however, continues on a good scale, and, though the price is on a high level, the undertone is on the whole firm. Metal continues to arrive more freely, and the higher prices will no doubt induce further shipments on a larger scale from across the Atlantic. Current quotations:—*Soft foreign (prompt)*: Thursday, £31 15s.; Friday, £32 5s.; Monday, £32 2s. 6d.; Tuesday, £32 5s.; Wednesday, £31 15s.

Mr. Gilbert Griffiths, the Midlands representative of the General Refractories Company, Limited, of Kelham Island Firebrick Works, Sheffield, has changed his address from 39, Brandon Road, Hall Green, Birmingham, to 3, Fernley Road, Sparkhill, Birmingham.

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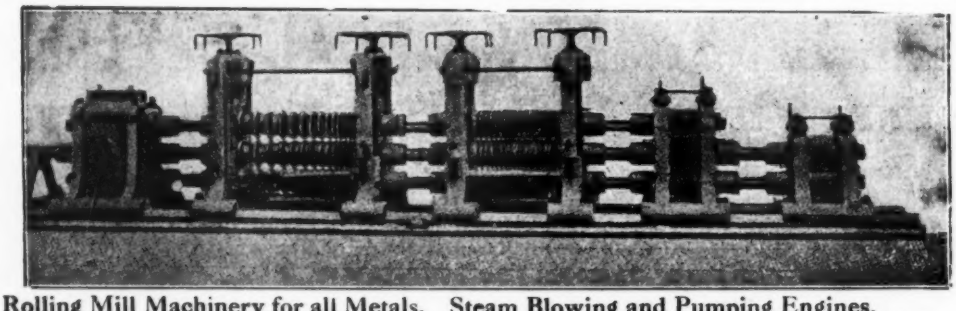

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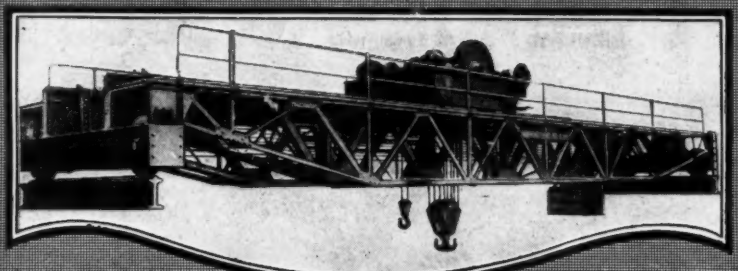

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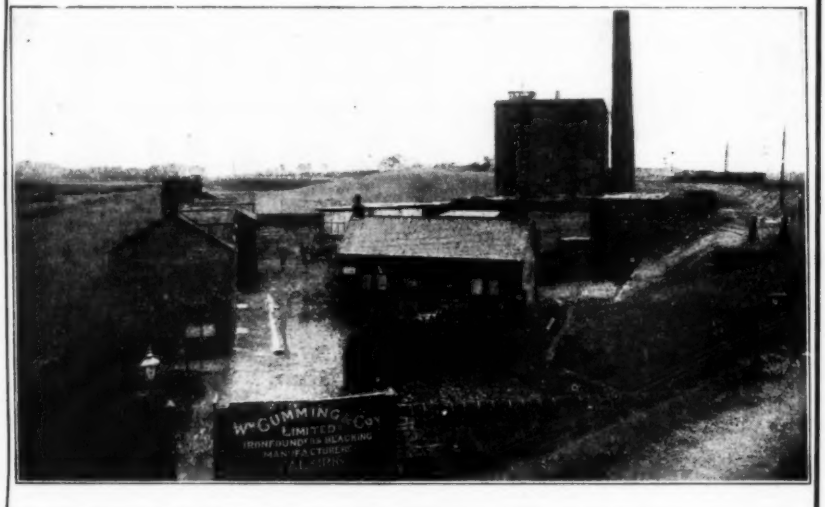

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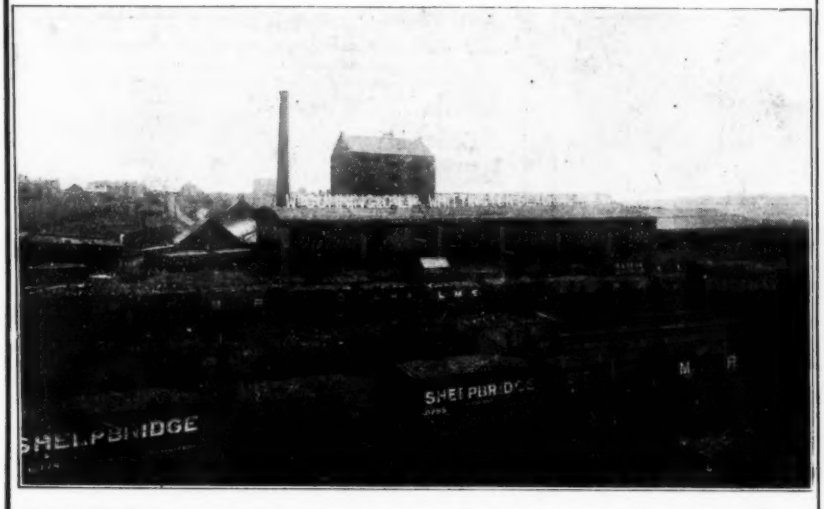

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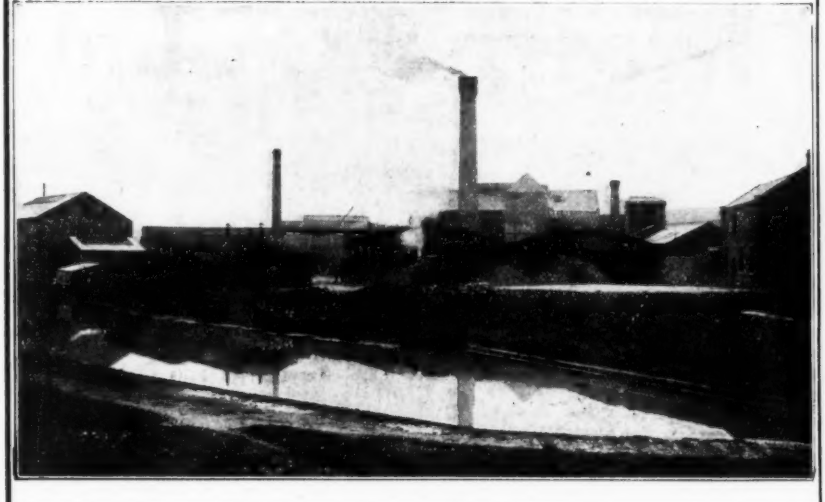

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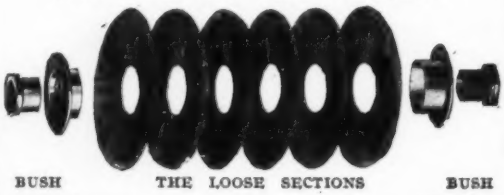
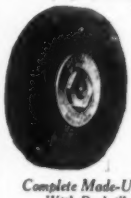
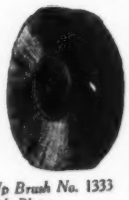


BUSH THE LOOSE SECTIONS BUSH



SIZES	SIZES
8 × 1½ IN.	8" DIAM.
10 × 1¾ IN.	10" DIAM.
12 × 2 IN.	12" DIAM.
15 × 2½ IN.	15" DIAM.



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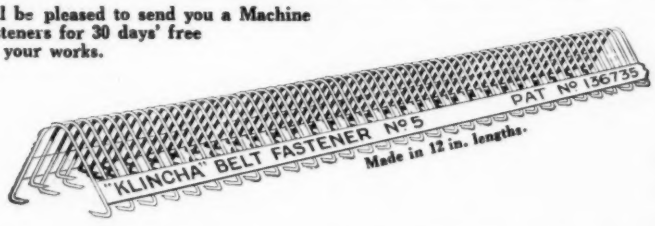

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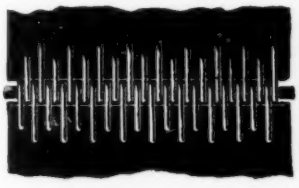

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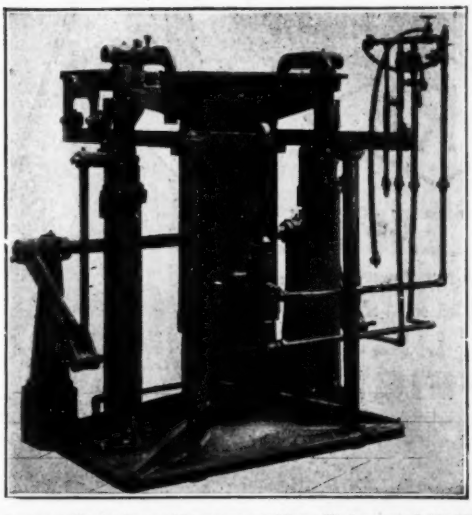

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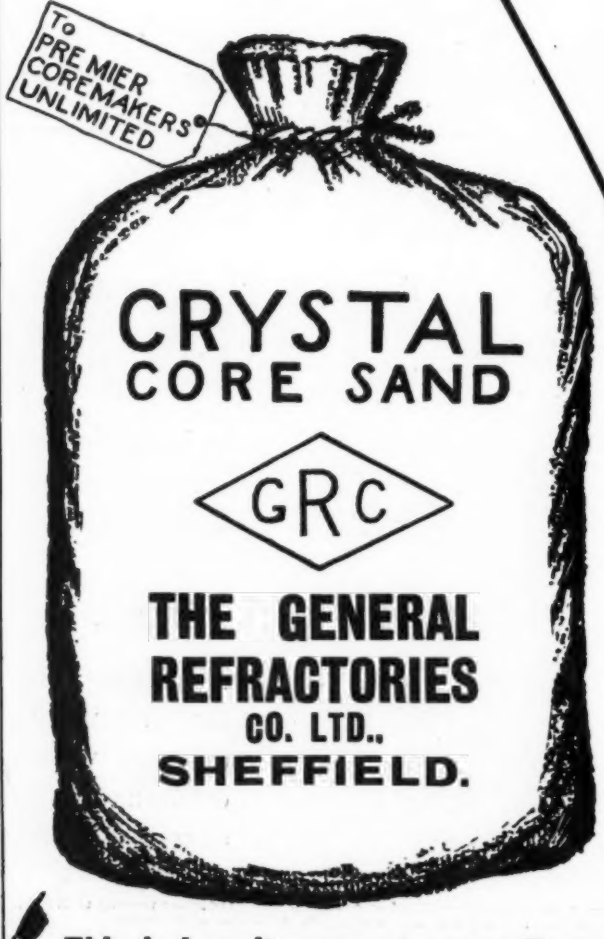

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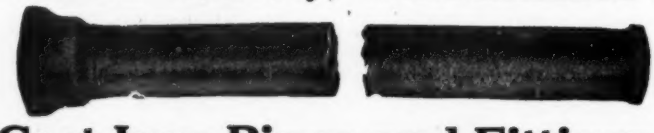

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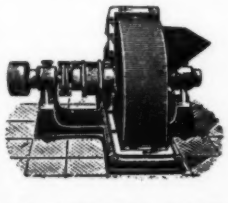

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Sheets ..	92	0	0
India ..	80	0	0
Wire bars ..	66	10	0
Do. July..	66	10	0
Do. August	66	10	0
Ingot bars ..	66	10	0
H.C. wire rods	71	10	0
Off. av., cash, May	62	1	4 4/11
Do., 3 mths., May	62	18	10 4/11
Do. Settlemnt, May	62	0	8 5/11
Do., Electro, May	67	18	2 8/11
Do., B.S., May	66	11	11⅓
Aver. spot price, copper, May	62	0	2¾
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Brazed tubes ..			13¼d.
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Standard cash	221	17	6
Three months	222	2	6
English ..	224	10	0
Bars.. ..	226	10	0
Straits ..	223	10	0
Australian ..	222	7	8
Eastern ..	226	0	0
Banca ..	225	15	0
Off. aver., cash May	218	13	0 5/11
Do., 3mths., May	218	0	10 5/22
Do. Sttlmnt. May	218	12	0 5/11
Aver., spot, May	218	7	6

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Ordinary ..	32	5	0
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India ..	29	10	0
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Zinc ashes	13	10	0
Off. aver., May	30	14	7 3/22
Aver., spot, May	30	13	1½

LEAD.

Soft foreign ppt	31	15	0
English ..	33	5	0
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35/40%	19/3 lb. va.
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70/75% c. free ..	9/3 lb.
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6/8% car. ..	£23 10 0
8/10% car. ..	£23 0 0
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Max. 2% car. ..	£42 0 0
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Per ton, unless otherwise stated.	

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Per lb. net, d/d steel makers' works.

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South Wales— Heavy steel	4	7	6	4	10	0
Bundled steel & shrngs.	4	2	6	4	7	6
Mixed iron & steel	4	0	0	4	5	0
Heavy cast iron	4	3	6	4	5	0
Good machinery for foundries	4	10	0	4	12	6
Cleveland— Heavy steel ..		4	3	6		
Steel turnings ..		3	7	0		
Cast-iron borings		3	4	6		
Heavy forge ..		5	15	0		
Bushelled scrap .		4	12	6		
Cast-iron scrap ..		4	6	9		
Lancashire— Cast-iron scrap ..		4	11	3		
Heavy wrought..		5	0	0		
Steel turnings ..		3	10	0		

London — Merchants' buying prices delivered yard.

Copper (clean) ..	55	0	0
Brass (clean) ..	39	0	0
Lead (less usual draft)	28	0	0
Tea lead	26	0	0
Zinc	20	0	0
New aluminium cuttings.. ..	95	0	0
Braziery copper	46	0	0
Gunmetal ..	44	0	0
Hollow pewter ..	145	0	0
Shaped black pewter.. ..	80	0	0

PIG-IRON.

(f.o.t. unless otherwise stated).

N.E. Coast—	
Foundry No. 1 ..	94/-
Foundry No. 3 ..	89/-
Forge No. 4 ..	87/-
Mottled	87/-
Hematite No. 1 ..	98/-
Hematite M/Nos. ..	97/-
N.W. Coast—	
Hem. M/Nos. d/d Glas.	107/6
„ d/d Birm. ..	117/6
Midlands—	
Staffs. common* ..	102/-
„ No. 4 forge	85/- to 87/-
„ No. 3 foundry	93/9
„ basic*	102/-
Shrops. Cold blast, ord.*	190/-
„ „ roll iron*	195/-
* d/d Birmingham.	
Northants forge	82/- to 85/-
„ fdry. No. 3	87/6 to 90/-
Derbyshire forge	85/- to 87/6
„ fdry. No. 3	92/6 to 95/-
„ basic	90/6
Scotland—	
Foundry No. 1 ..	103/-
„ No. 3 ..	98/-
Hem. M/Nos. ..	100/-
Sheffield (d/d district)—	
Derby forge	89/- to 92/-
„ fdry. No. 3	96/6 to 99/-
Lincs. forge	99/-
„ fdry No. 3 ..	100/6
E.C. hematite ..	107/-
W.C. hematite ..	112/6
Lincs. (at furnaces)—	
Forge No. 4 ..	90/-
Foundry No. 3 ..	91/6
Basic	90/-
Lancashire (d/d eq. Man.)—	
Derby forge ..	94/-
„ fdry. No. 3 ..	101/6
Northants foundry No. 3	105/-
Dalzell, No. 3 ..	115/6
Summerlee, No. 3 ..	115/6
Glengarnock, No. 3	115/6
Gartsherrie, No. 3 ..	115/6
Monkland, No. 3 ..	115/6
Coltness, No. 3 ..	115/6
Shotts, No. 3 ..	115/6

FINISHED IRON AND STEEL.

Usual District deliveries for iron ; delivered consumers' station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)	12	10	0	to 13	0	0
Angles	12	15	0	to 13	5	0
Tees to 3 united ins.	13	0	0	to 14	0	0
Nut and bolt	11	17	6			
Hoops	14	10	0	to 15	0	0
Marked bars (Staffs.) f.o.t. ..	15	0	0			
Gas strip ..	13	5	0			
Bolts and nuts, ⅜ in. × 4 in. ..	18	0	0			
Steel—						
Ship plates	£9/10	to	10	5	0	
Boiler plates ..	13	10	0			
Chequer plates ..	11	5	0			
Angles	9	10	0	to 10	0	0
Tees	10	10	0	to 11	0	0
Channels ..	8	17	6			
Joists	9	10	0	to 10	0	0
Rounds & squares 3 in. to 5½ in..	10	10	0			
Rounds under 3 in. to ⅜ in. ..	10	5	0			
Flats, over 5 in. wide and up ..	10	15	0			
Flats, 5in. to 1½in.	10	0	0			
Rails, hvy. ..	9	0	0			
Fishplates ..	13	0	0			
Hoops (Staffs.) ..	12	0	0			
Black sheets, 24 g.	13	0	0			
Galv. cor. sheets, 24 g. ..	18	0	0			
Galv. fencing wire, 8 g. plain ..	16	0	0			
Rivets, ¾ in. dia.	12	15	0			
Billets, soft	£7	15	0	to £8	5	0
Billets, hard	£10	to	£10	5	0	
Sheet bars	£8	3	9	to £8	5	0
Tin bars d/d (less rebate 7/6) ..	8	12	6			

PHOSPHOR BRONZE.

	Per lb.	basis.
Strip	1	2¾
Sheet	1	3¼
Wire	1	3¾
Rods	1	3½
Tubes	1	6½
Castings	1	1

Delivery 3 cwt. free.

10% phos. cop. £40 above B.S.

15% phos. cop. £50 above B.S.

Phosphor tin (5%) £30 above price of English ingots.

C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks ..	9d. to 1/5½
Ingots rolled to spoon size ..	1/- to 1/8½
Wire round—	
3/0 to 10 G. ..	1/6½ to 2/1½

with extras according to gauge.

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	21.76
No. 2 foundry, Valley	20.00
No. 2 foundry, Birm. ..	21.00
Basic	21.76
Bessemer	23.26
Malleable	21.76
Grey forge	21.26
Ferro-mang. 80% d/d	107.50
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y at mill	43.00
Bess. billets	38.00
O.-h billets	38.00
O.-h. sheet bars ..	40.00
Wire rods	48.00
	Cents.
Iron bars, Phila. ..	2.42
Steel bars	2.20
Tank plates	2.20
Beams, etc.	2.20
Skelp, grooved steel ..	2.20
Skelp, sheared steel ..	2.20
Steel hoops	2.75
Sheets, black, No. 28 ..	3.50
Sheets, galv., No. 28 ..	4.75
Sheets, blue an'l'd, 9 & 10	2.75
Wire nails	2.90
Plain wire	2.65
Barbed wire, galv. ..	3.70
Tinplate, 100 lb. box ..	$5.50

COKE (at ovens).

Welsh foundry	40/- to 45/-
„ furnace	27/6 to 35/-
Durham & North. fdy..	45/-
„ furnace	23/6 to 24/-
Other Districts, fdy.	45/-
„ „ furnace	22/- to 24/-

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes,	20×14, box	22/7½
„	28×20, „	45/3
„	20×10, „	33/9
„	28¾×14, „	23/9
C.W.	20×14, „	19/7½
„	28×20, „	42/10½
„	20×10, „	27/9
„	18¾×14, „	20/1½

Terneplates 28×20, 1/3 per box basis below tinplates.

SWEDISH IRON.

Bars, hammered	£23/10 to £24/5
Rolled Ord.	£18/5 to £18/10
Nail Rods ..	£18/10 to £18/15
Keg. steel	nom. £30 0 0
Faggot steel	nom. £22 0 0
Blooms, Sngle weld.	£10 to £12
Do. Single & double	£13 to £14
Pig-iron ..	£7/15 to £8 0 0

All f.o.b. Gothenburg:

TUBES.

	Up to and incl. 6 in.	
Gas	50%	Tube prices are now free.
Water	45%	
Steam	40%	

DAILY FLUCTUATIONS.

Standard Copper (cash).

	£	s.	d.		
June 19	60	17	6	dec.	5/-
„ 20	61	0	0	inc.	2/6
„ 23	61	0	0	No change	
„ 24	60	15	0	dec.	5/-
„ 25	60	12	6	„	2/6

Electrolytic Copper.

June 19	66	0	0	No change	
„ 20	65	10	0	dec.	10/-
„ 23	65	10	0	No change	
„ 24	65	0	0	dec.	10/-
„ 25	65	0	0	No change	

Standard Tin (cash).

June 19	217	15	0	dec.	110/-
„ 20	220	5	0	inc.	50/-
„ 23	223	0	0	„	55/-
„ 24	222	0	0	dec.	20/-
„ 25	221	17	6	dec.	2/6

Tin (English ingots).

June 19	221	0	0	dec.	60/-
„ 20	224	5	0	inc.	65/-
„ 23	226	15	0	„	50/-
„ 24	225	10	0	dec.	25/-
„ 25	224	10	0	„	20/-

Zinc Sheets (English).

June 19	37	10	0	No change
„ 20	37	10	0	„
„ 23	37	10	0	„
„ 24	37	10	0	„
„ 25	37	10	0	„

Spelter (ordinary).

June 19	31	7	6	dec.	11/3
„ 20	31	10	0	inc.	2/6
„ 23	31	17	6	„	7/6
„ 24	31	17	6	No change	
„ 25	32	5	0	inc.	7/6

Lead (English).

June 19	33	0	0	dec.	10/-
„ 20	33	10	0	inc.	10/-
„ 23	33	10	0	No change	
„ 24	33	10	0	„	
„ 25	33	5	0	dec.	5/-

BLAST-FURNACE STATISTICS.

Furnaces in Blast at the close of each Quarter making Pig-iron Specified.

Quarter ending.	Hematite.	Forge and foundry.	Basic.	Ferro-manganese	Total in blast.
1912					
March ..	16	26	7	6	55
June ..	103	163	47	12	325
September	113	170	49	15	347
December ..	115	171	49	15	350
1913					
March ..	118 2/3	169	52	18 1/3	358
June ..	117	163	50	14	344
September	107	157	47	13	324
December ..	91	154	55	13	293
1914					
March ..	96	146	47	11	300
June ..	90	143	45	12	290
September	94	133	41	15	286
December ..	100	136	46	12	294
1915					
March ..	102	130	52 2/3	10	294
June ..	103	126 1/3	54 2/3	10	294
September	105	117 1/3	52 2/3	11	287
December ..	108	111 1/3	50 2/3	15	284
1916					
March ..	116	106 1/3	50 2/3	12	285
June ..	120	106	54	13	293
September	124	107	58	13	302
December ..	126	110	57	18	311
1917					
March ..	131	111	62	16	320
June ..	129	116	70	15	324
September	123	102	78	19	322
December ..	118	99	85	13	315

Quarter ending.	Hematite.	Forge and foundry.	Basic.	Ferro-manganese	Total in blast.
1918					
March ..	117	102	92	15	326
June ..	120	108	86	16	330
September	120	104	83	14	321
December ..	113	108	72	15	308
1919					
March ..	98	109	69	13	289
June ..	97	107	78	7	289
September	66	99	53	5	223
December ..	77	113	62	8	260
1920					
March	92	108	72	10	282
June ..	97	119	68	12	296
September	93	122	73	12	300
December ..	77	125	50	13	274
1921					
March ..	36	70	10	3	119
June ..	—	1	—	—	1
September	17	41	10	—	68
December ..	22	41	15	3	81
1922					
March ..	31	46	23	7	107
June ..	25	55	28	9	117
September	27	74	27	10	138
December ..	46	83 1/3	30 2/3	10	170
1923					
March ..	52	93	45	10	200
June ..	62	103	45	13	223
September	38	98	42	11	189
December ..	50	99	49	9	207
1924					
March ..	45	94 2/3	51 1/3	10	201

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WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

18, BENNETTS HILL, BIRMINGHAM.

18, BENNETTS HILL, BIRMINGHAM.
11, OLD HALL STREET, LIVERPOOL.
EXCHANGE BLDGS., PORT TALBOT.
FOWLERS BUILDINGS, BOMBAY.
CLIVE STREET, CALCUTTA.
ANGAPPA NAICK STREET, MADRAS.

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OCEAN BUILDING, SINGAPORE.
JAVA STREET, KUALA LUMPUR
5, SHAFFRAZ ROAD, RANGOON.
COX'S BUILDINGS, KARACHI.
P.O. BOX 1580, CAIRO.

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SCOTCH, MIDDLESBRO', HEMATITE, BASIC, SPECIALS, &c.,

FLUOR SPAR

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

WILLIAM COLVIN & COMPANY,

ROYAL EXCHANGE, MIDDLESBROUGH.

93, HOPE STREET, GLASGOW.

SMALL ADVERTISEMENTS.

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SITUATIONS VACANT AND WANTED.

IRON AND BRASS FOUNDRIES—YOUR ATTENTION, PLEASE.

FOUNDRY ENGINEER—FULLY QUALIFIED—WITH EXTENSIVE AND VARIED EXPERIENCE, IS DESIROUS OF HEARING FROM FOUNDERS WHO WISH TO REORGANISE THEIR WORKS (PART OR WHOLE). ADVERTISER UNDERTAKES PLANNING OF SCHEMES, AND ADVISES IN THE FOLLOWING BRANCHES:—FINANCE, PLANT, PURCHASING, GENERAL PRODUCTION AND COSTS, CUPOLA PRACTICE AND CASTING PROBLEMS, MOULDING METHODS, ETC.—WRITE IN FIRST INSTANCE TO BOX 788, FOUNDRY TRADE JOURNAL, BESSEMER HOUSE, 5, DUKE STREET, ADELPHI, STRAND, LONDON, W.C.2.

GENTLEMAN, trained engineer, shops, D.O., estimating and sales office, erection superintendent, representative, desires Staff Appointment or as Representative with Manufacturing Engineers or Agents; foundry plant, iron and steel works plant, castings; small investment considered.—Box 850, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

MANAGER OR SUPERINTENDENT requires appointment to take entire control of Foundry, Iron, Steel or non-Ferrous; thorough metallurgical training and foundry experience.—Box 852, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

COMPETENT PATTERN MAKER required in London for small castings; single man about 30.—Full particulars of experience and wages required, Box 838, Offices of THE FOUNDRY TRADES JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

FIRST CLASS MOULDERS wanted, used to Dry or Green Sand for Machine Tool work.—ALFRED HERBERT, LIMITED, Edgwick Works, Coventry.

FOREMAN MOULDER required, used to Castings (grey iron) in Loam, Green and Dry Sand, up to 5 tons. (London District.)—Apply, giving fullest particulars to Box 856, Offices of the FOUNDRY TRADE JOURNAL, 5, Duke Street, Adelphi, London, W.C.2.

WANTED at once, Working Foreman for Malleable Foundry; machine moulding. Experience essential.—Apply, with full particulars, to Box 836, Offices of THE FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

EX-OFFICERS AND OTHER RANKS.

The Proprietors of the FOUNDRY TRADE JOURNAL have placed this space at the disposal of the District Director, 3-4, Clement's Inn, W.C., to whom all replies should be addressed, quoting number of advertisement, the date on which it appeared, and name of this paper.

EX-OFFICER, age 42, married, 5 years' war service, desires post Commercial Traveller; 5 years' apprenticeship Wholesale Ironmongery; experienced representative Gas-stove and Geyser Manufacturers; good connection with Gas Undertakings in London, South Eastern and Eastern Counties; has good clerical and store-keeping experience and is willing to take any post. (5405/TP.)

EX-OFFICER; age 31; single; 5 years' war service; educated Public School; fluent French; served regular apprenticeship chemical engineering; sound technical knowledge; expert knowledge of wireless telephony, all branches; experienced representative salesman; specialist I.C. engines; good organiser, able to control; thorough knowledge of office routine; willing to take any post. (41310.)

EX-OFFICER, age 39, married, 4 years' war service, educated Public School, University B.A. (Lond.), B.Sc. (Durham), experienced in Silica Magnesite, Chromes and Fireclay Refractories, Building Pavey Bricks and Tiles, trained Engineer, well versed in costs and accounts, able to lay out new works, desires post as Brickworks Manager, and is willing to take any position. (19582/Eng.)

EX-OFFICERS & OTHER RANKS.—*Continued.*

DREDGING.—Ex-Officer, age 47, single, war service; qualified Civil Engineer; experienced road and railroad construction abroad; land surveying and topographical work; expert in gold dredging, hydraulicing, etc.; thorough knowledge construction of masonry and reinforced concrete bridges; French and modern Greek fluent; is willing to take any post. (84806/Eng.)

PUBLICATIONS.

BRASS AND IRONFOUNDERS who are eager to advance their positions should send at once for the "Foundrymen's Educator," post free 5s. Do not hesitate, while you are doing this you are losing money. Make yourselves capable of writing for good positions advertised, also securing them. A comfortable berth and salary is better than working hard all your lives at a low wage. Write at once.—GREAVES, Harefield Hall, Heywood, near Manchester. Time is money to the Foundryman.

MACHINERY.

FOUNDRY SAND MIXERS for 1, 2 and 4 tons per hour; all latest improvements; soiled only; special prices to clear.—Send your inquiries, please, to W. BREALEY & COMPANY, LTD., Russell Street, Sheffield.

MACHINERY, PLANT, &c.

Set of Nearly New THREE-THROW HYDRAULIC PUMPS, 4 in. rams, 12 in. stroke; working pressure, 1,500 lbs.; driven by 130 h.p. D.C. Motor, 500 volts.

Set of HORIZONTAL THREE-THROW HYDRAULIC PUMPS, 3½ in. rams, 12 in. stroke, by Hy. Berry & Co., Ltd.; working pressure, 1,500 lbs.

Worthington HORIZONTAL DUPLEX PUMP, 14 in. x 12 in. x 10 in.; 10 in. suction, 8 in. delivery.

Worthington DUPLEX DOUBLE-ACTING PLUNGER PUMP, ring pattern; 16 in. cyl., 8½ in. plunger, 10 in. stroke.

NEARLY NEW STEEL LANCASHIRE BOILER, 30 ft. x 9 ft.; reinsurable at 100 lbs. working steam pressure; complete with steam and furnace fittings, etc.

Six very good dish-ended LANCASHIRE BOILERS, by Thompson; 30 ft. x 8 ft.; reinsure for 150 lbs. per sq. inch working pressure; ready for despatch.

LANCASHIRE BOILER, 17 ft. x 5 ft. 6 in. diameter; reinsure 80 lbs. pressure.

FOUR MARINE WATER-TUBE BOILERS, by Yarrow, Ltd.; each 4,000 sq. ft. heating surface; reinsure 200 lbs. pressure.

LOCO-TYPE BOILER; barrel 4 ft. 7 in. long x 3 ft. diameter; reinsure 80 lbs.. pressure.

21 CLOSED TOP TANKS, each 9 ft. 9 in. x 5 ft. x 4 ft. deep; plates ¼ in. thick; capacity about 1,218 gallons, with opening in top 5 ft. x 3 ft. 9 in.

Catalogue of Stock Machinery, 6,000 lots, free on application. Inspection invited.

THOS. W. WARD, LTD.,
ALBION WORKS, SHEFFIELD.
PALACE OF ENGINEERING,
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MOULDING MACHINES FOR SALE; 20 to 30 various sizes, by Darling & Sellars, Ltd.; almost new and in excellent working order; can be inspected any time by appointment.—THOMAS L. HALE (TIPTON), LTD., Dudley Port, Tipton, Staffs.

WANTED, Back-type Coal Fire Annealing Furnace; capacity approximately 250 c. ft.; must be in excellent condition. State price and where could be seen.—Box 854, Offices of THE FOUNDRY TRADE JOURNAL, 5, Duke Street, Adelphi, London, W.C.2.

Worm & Bevel-Geared Crane Ladles

½ Ton EVANS	£10
1 Ton THWAITES ..	£18
2 Ton EVANS	£28
3 Ton EVANS	£38
4 Ton EVANS	£44
5 Ton STEVENSON ..	£44

Any Ladle sent *On Approval*

4-foot self-discharging sandmill	£22
Spermolin coremaking machine with dies	£16
Two heavy Jackman D.E. roller bearing grinders, each	£24
Two Jackman geared rumbling barrels, each	£13
Portway Cokefired corestove	£18

LARGEST STOCK OF FOUNDRY PLANT.

PLEASE SEND FOR FULL LIST.

ALEX. HAMMOND, "BOXTED," SLOUGH.

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EXHIBITION VISITORS can obtain Free Handbook and Information respecting Patents for Inventions, Trade Marks, etc., from B. T. KING, Regd. Patent Agent, 146A, Queen Victoria Street, E.C.4.

MISCELLANEOUS.

COKE.—Furnace Coke, 27s. ton, Ovens; Breeze, 26s. 6d.; Foundry Coke, 43s. 6d. Anthracite Washed Beans for Suction Gas Plants, 28s. ton pit; Anthracite Cobbles 29s. 6d. pit; Sem Anthracite (reg.), 25s. 6d.—BUCKLE COLLIERY CO., 97, Hales, Cheltenham.

SMALL IRON CASTINGS can be made Malleable in London at "Snow's" Malleable Iron Works. Send samples and procure lowest price. 247, Shakespeare Road, S.E.24.

Be rid of rust!

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"Ruskilla" is the paint for your job. It kills the rust and stands up to abnormal conditions. Being elastic, it does not crack or peel under vibration or temperature variation.

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Applicable to all phases of Heat Treatment and all Fuels.

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GAS FURNACES A SPECIALITY.

Uniform Heating, Economy in Fuel, Increased Production, Low Maintenance Costs, Improved Quality of Product.

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Telegrams: "Repeat," Birmingham. **SMETHWICK.** *'Phone: 275 & 276 Smethwick.*

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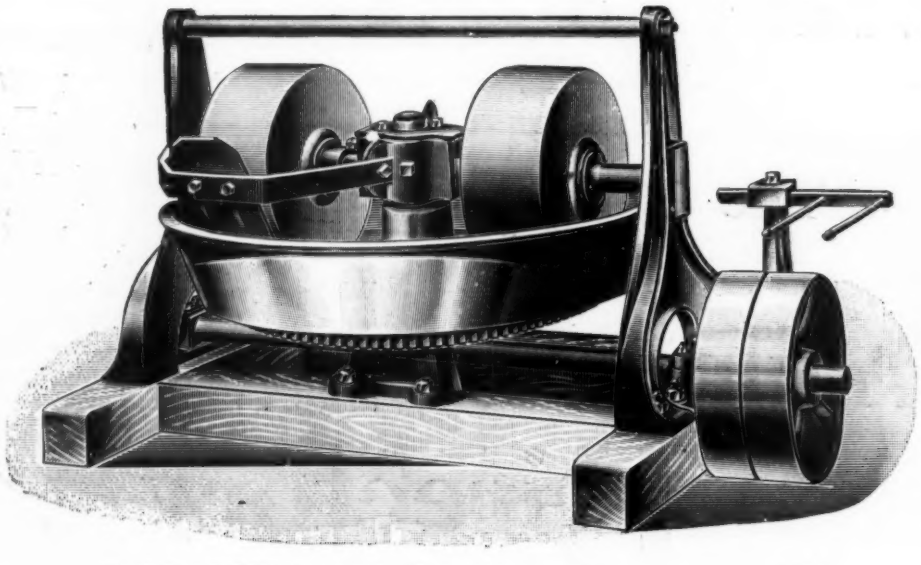

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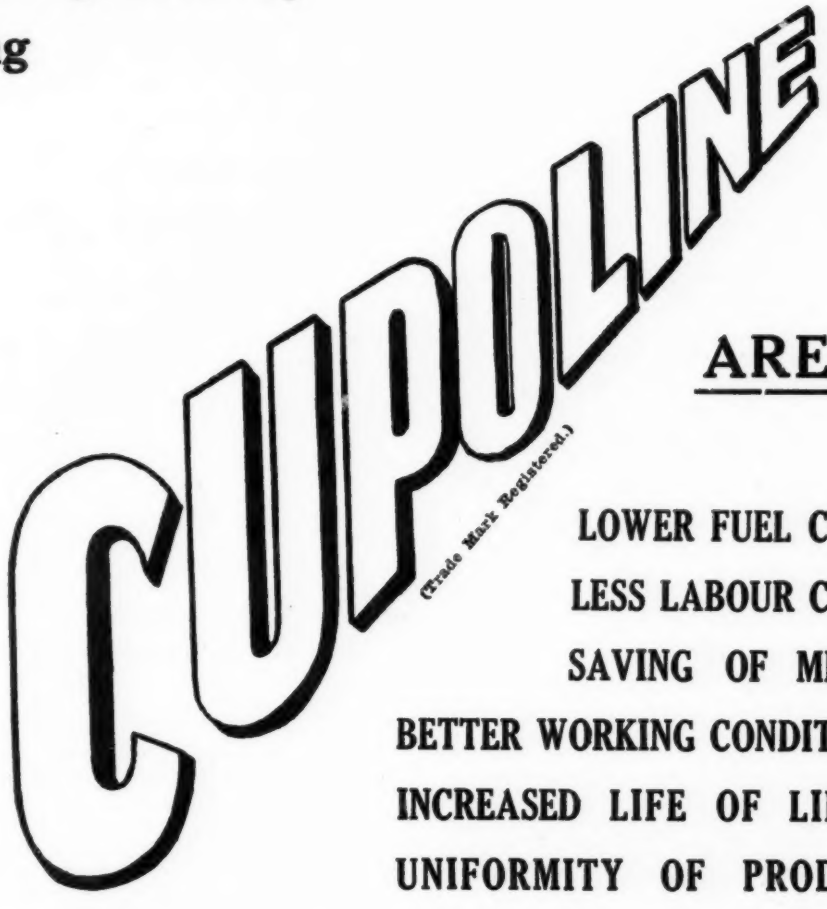

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Silicon	1.30	to 1.50	1.20 to 1.50	0.80 to 1.20	0.50 to 1.10	0.45 to 0.70	0.45 to 0.50
Sulphur	0.042	to 0.07	0.02 to 0.08	0.04 to 0.10	0.15 to 0.07	0.15 to 0.12	0.17 to 0.20
Phosphorus	..	—	0.35 to 0.45	0.35 to 0.50	0.35 to 0.50	0.35 to 0.50	0.35 to 0.50
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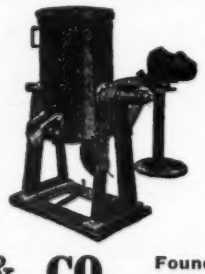

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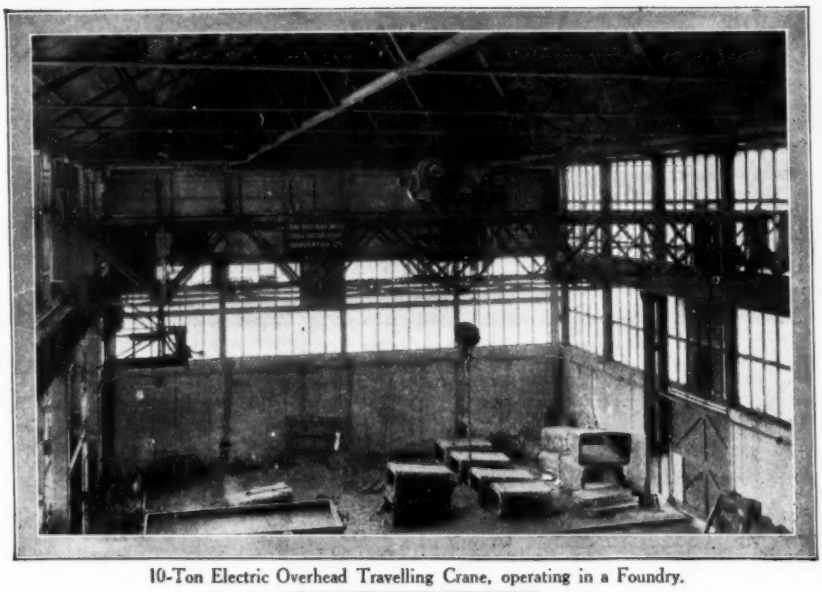

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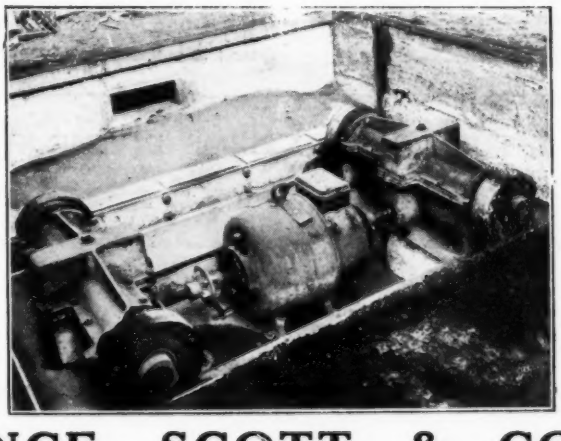

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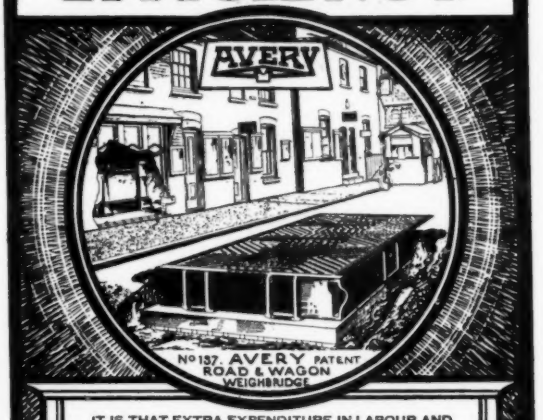

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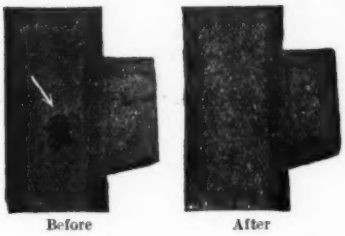

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